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Editorial.

Agricultural Conference.

THE Third Agricultural Conference was opened by His Excellency the Governor (Sir Herbert James Stanley, K.C.M.G.) on May 7th and a number of questions of importance to the agricultural prosperity of Ceylon was dealt with. The attendance was again greater than in previous years and the discussions were much keener and of greater interest.

His Excellency the Governor presided over all the sessions and by his attendance and participation in the discussions showed the keen interest he has in all matters affecting the agriculture and the general prosperity of the Colony.

The Conference by bringing together scientific workers, with data concerning the problems on which they are working, and practical men, with their experience, enables a free interchange of views. The very essence of the conference is to assist co-operation between the scientific workers and the practical agriculturists. The exchange of views on problems requiring investigation and upon the application of the results of research is most desirable. It leads to progress and to the formulation of work on estates and to agricultural policies generally along lines which are based upon scientific data. The personal contact between workers is of the greatest value. Each learns from the other, and it is only by this free exchange of views and information that sound progress is effected. It enables the scientific worker to learn the problems of the practical man and the latter to learn the results that have been secured from the investigations which are in hand.

The Proceedings of the Conference will be issued in the May and June numbers of the *Tropical Agriculturist*.

Programme of Agricultural Conference at Peradeniya, 1928.

Monday, May 7, Morning Session.

9-30 a.m. to 12 noon.

OPENING ADDRESS BY HIS EXCELLENCY THE GOVERNOR.

Paper.—Some problems for the Tea Research Institute, by Mr. T. Petch, B.A., B.Sc., Director, Tea Research Institute.

Discussion on above.—The following points submitted by various Distirct Planters' Associations will be dealt with during the discussion on the above paper:—

Kandy District Planters' Association.— Branch Canker (Wood Rot) and its connection with season of pruning, style of pruning, and Shot-hole Borer infection.

Morawak Korale Planters' Association.—

(a) Shade trees suitable for elevations of 1,500-3,000 feet.

(b) Fuel trees for elevations of 1,500 feet.

(c) The relationship, if any, between Boga medeloa and prevalence of Shot-hole Borer.

Monday, May 7, Afternoon Session.

2 p.m. to 4-30 p.m.

Discussion: The Uda Hewaheta District Planters' Association.—The relationship between manuring and callus formation in tea. This discussion will be led by Mr. P. A. Keiller.

Papers.—Manurial Investigations.

(a) The results of drainage and leaching trials at Peradeniya during 1927, by Mr. A. W. R. Joachim, B.Sc., A.I.C., Agricultural Chemist, Department of Agriculture.

(b) Experiences in the use of creeping cover crops in tea cultivation, with special reference to *Indigofera endecaphylla*, by Mr. T. H. Holland, Dip. Agric. (Wye), Manager, Experiment Station, Peradeniya.

Discussion.—The following points have been submitted for discussion:—

Kandy District Planters' Association.—

(a) Chemical manures and the amounts a tea bush is able to absorb with beneficial results.

(b) The effects of a sudden stoppage of chemical manures, more especially those used as a top dressing.

Tuesday, May 8, Morning Session.

9-30 a.m. to 12 noon.

Paper.—Soil erosion with special reference to rubber, by Mr. C. E. A. Dias.

Discussion.—Cover crops and green manuring in rubber cultivation.

This discussion will be opened by Mr. J. Mitchell, A.R.C.S., Secretary, Rubber Research Scheme, and the following points submitted by various District Planters' Associations will be dealt with during the discussion:—

Kelani Valley Planters' Association.—

(a) How is the maximum benefit from different green manures and cover crops to be secured ?

(b) What is the optimum period of retention without rooting out the cover crops and replanting ?

(c) The desirability or otherwise of burying leaf.

(d) The best methods of applying artificial fertilizers to soils under cover crops.

Kandy District Planters' Association.—The use of artificial manures forked into the soil in the control of Oidium.

Paper.—Some notes on the budding of rubber and the transport of bud-wood, by Mr. T. H. Holland, Dip. Agric. (Wye), Manager, Experiment Station, Peradeniya.

Tuesday, May 8, Afternoon Session.

2 p.m. to 4 p.m.

Some notes on Factory procedure and efficiency, especially in reference to Crêpe manufacture by Mr. T. E. H. O'Brien, M.Sc., A.I.C., Chemist, Rubber Research Scheme.

Inspection of Laboratories.

Wednesday, May 9, Morning Session.

9-30 a.m. to 12 noon.

Paper.—Dairy Farming and Breeding of Stock in the Kurunegala District, by Mr. R. M. Fernando.

Discussion on Cattle Breeding in Ceylon.

Paper.—Some of the limiting factors in the improvement of paddy cultivation in Ceylon, by Mr. L. Lord, M.A., Economic Botanist, Department of Agriculture.

General discussion of means of improving conditions of tenure between landlord and tenant.

Paper.—Some aspects of food Production, by Mr. H. L. De Mel, C.B.E.

Wednesday, May 9, Afternoon Session.

2 p.m. to 4 p.m.

Inspection of Laboratories and Experiment Station, Peradeniya.

4-30 p.m.—Inspection of Farm School, Peradeniya.

5-15 p.m.—Prize Giving, Farm School, Peradeniya.

Evening 9 p.m.—The use of the magic lantern for pest protection work by Mr. N. K. Jardine, F.E.S., Plant Pest Inspector, Central.

Thursday, May 10, Morning Session.

9-30 a.m. to 12 noon.

Paper.—Investigation of root diseases of coconuts, by Mr. M. Park, A.R.C.S., Assistant Mycologist, Department of Agriculture.

Paper.—The Marketing of Produce, by Mr. G. Robert de Zoysa.

Paper.—Bee Culture, by Mr. A. P. Goonatilleke.

Thursday, May 10, Afternoon Session.

2 p.m. to 4 p.m.

Paper.—The development of the Wanni from the point of view of the people of Jaffna, by Mr. W. P. A. Cooke, M.Sc., Divisional Agricultural Officer, Northern Division.

Paper.—The economic development of the Dry Zones of the Island with special reference to the work of the Department of Agriculture on the rotation of crops, by the Director of Agriculture.

Close of Conference by His Excellency the Governor.

The Third Agricultural Conference at Peradeniya, May 7th-10th, 1928.

May 7th, 1928.—Morning Session.

THE Third Agricultural Conference was opened at the Board Room of the Department of Agriculture. His Excellency (Sir Herbert J. Stanley, K.C.M.G.,) presided, and there were also present Mr. H. W. Codrington, Government Agent, Central Province, the Hon. Mr. F. A. Stockdale, C.B.E., the Director of Agriculture, Sir Solomon Dias Bandaranaike, the Hon. Mr. A. Mahadeva, the Hon. Mr. J. W. Oldfield, the Hon. Mr. A. C. G. Wijeyekoon, the Hon. Mr. W. A. de Silva, Mrs. F. A. Stockdale, Mrs. T. H. Holland, Mrs. J. P. Obeyesekere, Mrs. P. E. Pieris, Mrs. Gordon Pyper, Mrs. H. C. Weekes, Mrs. R. A. Taylor, Mrs. J. C. Haigh, Mrs. A. L. Dassenaike, Mrs. C. N. E. J. De Mel, Mrs. A. Godamune, Gate Mudaliyar A. E. Rajapakse, Dr. S. C. Paul, Dr. A. Nell, Dr. W. Small, Dr. J. C. Hutson, Messrs. R. G. Coombe, John Horsfall, A. R. Westrop, T. Petch, T. Eden, R. C. Byng, P. A. Keiller, A. Bruce, E. C. Villiers, C. V. Brayne, G. W. Sturgess, A. A. Bowie, A. T. Sydney Smith, A. N. Philbrick, J. P. Obeyesekere, Frank Solomons, G. Robert de Zoysa, Victor Mendis, C. A. M. de Silva, Allen Coombe, J. W. Scott, D. G. Pandittasekera, T. H. Holland, Shelton de Alwis, A. H. G. Alston, M. S. Mendis, J. H. Meedeniya, Adigar, Mudaliyar C. G. de Alwis, Messrs. A. P. Coombs, H. A. Deutrom, J. C. Drieberg, E. W. Dias Bandaranayake, John E. de Silva, M. W. Jayesuriya, C. B. Herat, W. A. Perera, S. P. Charles, C. D. Paul, Wace de Niese, C.E.A. Dias, E. A. Peries, W. R. C. Paul, H. L. De Mel, C.B.E., the Rev. John E. Peries, Messrs. Gordon Pyper, R. Massy, H. C. Weekes, Malcolm Park, J. C. Haigh, James Ferguson, George Roberts, W. Molegode, J. C. Kelly, Oscar Johnson, E. C. Faulkner, W. A. Amerasekera, S. Muttutamby, P. G. Saminathan, J. A. B. MacKelvie, P. B. Nugawela, K. Bandara Beddewelle, J. I. Gnanamuttu, J. C. Ratwatte, George E. de Silva, S. Pararajasingham, T. E. H. O'Brien, R. K. S. Murray, W. P. A. Cooke, K. S. Arumugam, H. G. O'Connell, Harry Jones, L. Dawson Campbell, James Mitchell, J. H. Armitage, A. McLaren, L. Lord, F. Burnett, R. A. Taylor, E. K. Power,

S. R. Hamer, B. M. Selwyn, Huntley Wilkinson, A. M. Clarke, W. C. Lester Smith, C. Bourchier, J. J. Nock, F. R. Dias, St. L. H. de Zylva, M. J. Fernando, A. D. W. Gunetilleke, C. H. Lambert, A. D. Campbell, A. W. R. Joachim, G. E. J. Hulugalle, F. J. S. Turner, J. D. Sargent, Mudaliyar A. L. Dassenaike, Messrs. L. A. Wright, A. Hall, R. S. Hall, J. O. Widdows, H. A. Webb, Major C. L. de Zylva, Messrs. R. de V. Godfray, R. Hawkeswood, J. P. Blackmore, E. O. Felsinger, A. Godamune, A. P. Goonatilleke, Mudaliyar M. S. Ramalingam, Messrs. C. Muttiyah, R. M. Fernando, Mudaliyar Harry Jayawardene, Messrs. C. N. E. J. De Mel, A. C. E. Wanigasekera, R. Senanayake, S. Kandiah, C. Bandaranaike, H. T. de Silva, Mudaliyar W. Samarasinghe, Messrs. L. S. Bertus, G. D. Austin, A. W. Kannangara, H. Ludowyke, M. P. D. Pinto, L. J. Peter Perera and others.

The Hon. Mr. F. A. Stockdale, Director of Agriculture, in asking His Excellency the Governor to declare the Conference open, said:—Your Excellency, Ladies and gentlemen. This is the Third Agricultural Conference held in this Hall and it is a great privilege to us all to have Your Excellency here with us to-day. I think I am voicing the sentiments of all when I say that we greatly appreciate your decision, Sir, to preside over all our sessions.

Opening Address by His Excellency the Governor.

Mr. Stockdale, ladies and gentlemen,—I think it may help you to support the burden which I am about to inflict upon you if I give you permission to smoke during my speech as well as afterwards. I should like to preface my remarks by expressing my great pleasure in being able to come here and I thank the members of this Conference for giving me the opportunity of presiding over their deliberations. I have come here not to teach but to learn. It is a trite and obvious saying that agriculture is ultimately the foundation of all prosperity and wealth of a country. Whether it is true of all countries or not, it is certainly true of Ceylon, and we expect it will be true of Ceylon in the future. Ceylon has been and will always remain predominently and primarily an agricultural country, and therefore, it is obviously the duty of the Government and of the Governor to do what they can to acquaint themselves with the problems of agriculture and with the needs of the agricultural population, with a view to affording such assistance as might legitimately be within their power to those who are engaged in this all-important industry. I need not, of course, pretend to give you advice on any technical matters. We have here with us a number of technical experts and a number of practical men and I hope they will always find themselves in agreement with one another.

I notice on the two previous occasions the Governor in his opening address gave something in the nature of a survey of the work which the Government had been doing for agriculture during the preceding year. A detailed review of that nature would not be suitable on this occasion even if time permitted. Agriculture in one form or another is connected with almost every problem with which the Government has to deal and is in one way or another affected by every activity which the Government undertakes. There are, however, one or two principal aspects on which I might say a few words. The first subject which affords an opportunity for Government to give help to the agricultural industry is in respect of scientific and agricultural research. It is quite unnecessary that I should endeavour to impress upon you the importance of such. You are, of course, as well aware of its value as I am.

At the last Conference something was said about the necessity for the application of research work to the coconut industry of this country. I think there is great force in that contention and the Government has done its best to prepare the way for suitable action, and we have after very careful consideration, with our advisers, the Executive Council, drafted an Ordinance which is shortly to be laid before the Legislative Council. It has been published quite recently, and I presume that most of you are generally acquainted with the trend of its provisions. I am not going, therefore, to deal with it in detail. What we want to do in respect of the coconut industry as well as all other industries is not so much to spoon-feed them as to offer help where help is needed and to help it in such a way as to enable an industry to stand on its own feet and conduct its own research eventually without any kind of spoon-feeding from the Government. We do recognise that in the coconut industry there is some lee-way to be made up and that Government has not, in the past, done as much for the coconut industry as it has done for other great industries of this country, and to my mind, provision must be made to be more helpful at the outset than would be legitimate in the very strict definition of the functions of Government towards research. It is essential, of course, that research works should be so arranged as to avoid overlapping with the work which is being done by the Department of Agriculture and it should be supplementary and complementary to that work so that there will be no competition and unnecessary duplication of efforts by the Government and the industry in their respective spheres, but each should supply what it is best fitted to supply towards a common end. We have decided as you know, in regard to the coconut industry that Government should make itself responsible for half of the estimated cost of the proposal for the first 12 years, and we have also agreed to advance the whole of the funds neces-

sary for the establishment of an Experimental Station and its equipment. We propose, further, to entrust the management of the scheme to a Board consisting of representatives of the Government, the Legislature and the industry itself. I do not want to say anything more about this proposal. It will shortly come before the Legislative Council and I would only express the earnest hope that it will be possible for the Legislative Council to put into force a measure which will be of lasting benefit to a very important industry like the coconut industry.

Now about the tea industry, I need not say very much about that. It is highly organized and does not require any special help from the Government. The tea industry has been in a position to provide for the bulk of its research work by itself, and no doubt the great amount of work done by the Department of Agriculture in Peradeniya and elsewhere is immensely helpful to the special research work carried on by the industry itself. We are not at the moment called upon to elaborate anything like a scheme for tea research to be undertaken by the Government.

In the case of rubber, it is slightly different. I do not want to say very much about rubber. We all feel great sympathy with those engaged in the rubber industry in the uncertainty and loss they are sustaining owing to the fall in prices. We all hope that that loss and uncertainty will be transitory and that it will not be long before the industry recovers something like normal stability and normal prosperity. As you know the end of the present Restriction Scheme is in sight and that has created in some measure a new situation so far as our rubber research is concerned. It is our desire to widen the scope of the Ceylon Rubber Research Scheme in such a way that the funds necessary for its maintenance will be secured in the industry as a whole instead of only from some of the firms or companies or planters engaged in the industry as at present. We think it desirable that the industry should contribute as a whole, so that everybody engaged in rubber planting will be entitled as a right to benefit by the information which the research scheme has collected. At present, no doubt, you are all aware that the research scheme is maintained by only a portion of the industry who have generously placed the results of research at the disposal of all, whether subscribers or not, but those who were not subscribers could not claim that help as a right and therefore, it is desirable that the research scheme should be established on a broad and more comprehensive basis. Now it is our intention also to liberate as soon as may be practicable the moneys in the present Restriction Fund for the furtherance of research work. The objects we have especially in view are the investigation in the selection and isolation of high-yielding strains and the establishment of seed gardens, the two objects being really complementary to each other. You have to test your seed

by practical experiment and no amount of budding will enable you to dispense with seed selection on a large scale and we hope, therefore, that with the liberation of these funds, the Government will be in a position to establish, or at any rate initiate, a rubber research scheme which will be of great benefit to the industry. If there is to be a diminution in the selling price of rubber—and that seems inevitable—whether or not restriction is maintained, it is obviously necessary that the cost of production of the article should be reduced as low as possible and that efficiency of production should be stimulated as much as possible. I am sure that any money spent on research, if it is judiciously and wisely expended, will be of lasting benefit to the whole industry.

Now, of course, the object of all these research schemes from the point of view of the Government is not to help any particular industry but to assist in maintaining the prosperity of the country as a whole. The prosperity of a country depends very much on its agricultural production and the agricultural production of the great planting industries in particular and if we allow those industries to suffer, the suffering would be extended very much further than the people directly engaged in the industry. We look to the industries indirectly for the provision of the revenue to make it possible for us to do what we are doing and I hope is will, for the people as a whole, make it possible for us to do a great deal more in the future, so that the people in this country generally may benefit in the way of education, medical and sanitary services, and other works which the Government is undertaking to do.

There is one industry which is not highly organized and which I always felt is not as prosperous as it might have been and that is the great staple industry of paddy. The Government has a very strong duty in my opinion towards the cultivators of paddy. Paddy is the staple food of the country, and I might say it was a surprise and a disappointment to me when I came to Ceylon to find that although it is popularly regarded as a paddy growing country, it did not produce more than half the paddy that is consumed and it is necessary to import large quantities of rice which might be equally well grown here. Well, I know that paddy growing is not quite a simple matter when you come to look at it in practice. We are not going to advance any particular theory on the subject except to say that it is the duty of the Government to do what it can to help paddy growing which is in even greater need of help because it is less organized and less prosperous than any other planting industry which I previously referred to, and I am glad to note that the Director of Agriculture takes a similar view and is in many directions endeavouring to help these poor cultivators who are not sharing in the general prosperity of the country as much as it is desirable. I myself have taken an interest in paddy cultivation since my arrival in the Island

and I have used every opportunity which has come in my way of seeing something of the conditions under which the industry is carried on. I have also seen some great irrigation works which are now being completed. I have also seen something of the seed stations which have been established by the Agricultural Department with a view to discovering the best kind of seed for a particular locality. I think all these activities if they do not produce striking and immediate results must eventually redound to the benefit of the paddy grower and will ultimately make it far more easy to produce paddy economically with a reasonable profit. One hears views of all kinds as to the comparative lack of prosperity of the paddy grower. It is according to some due to the prevailing conditions of land tenure. Others say it is due to the relations between the landowner and the tenant. Others again say that it is a question of the lack of a water supply. Others say that what is really needed is an improvement in the type of seed and improvement in the methods of agriculture. There may be some truth in all these observations and it is the function of the Government, so far as it is possible to interfere at all, to consider any suggestions of that kind which is put before it and to give a helping hand where possible. Of course, we have to be very careful before we attempt to interfere with old-established customs. It has been found in other countries that a custom which on theoretical grounds is open to criticism, is so deeply rooted in the traditions and habits of the people that one must be very careful how one interfere with it, and if one interfere at all, that interference must not be too rapid or too drastic. I think possibly one hears criticisms of landlords being unduly exacting and one hears it said that the exaction of half the produce acts as a bar to enterprise on the part of the cultivator. There may be some truth in those criticisms and yet one ought not to endeavour to sweep away by one stroke of the pen the different systems on which this has arisen. This and others are subjects on which I do not profess to record any opinion; if they should arise in the course of the discussions, I will listen to what may be said with great interest and with a desire to clear my views on the subject which at present are rather hazy.

Another work on which the Department of Agriculture is engaged in and which must by everyone be regarded as work of great importance is an endeavour to help the cultivators in the Dry Zone. This is really a restatement in other terms of what is commonly known as the chena cultivation. Chenaing is not peculiar to Ceylon. In the country where I last administered, Northern Rhodesia, there was a similar system on a larger scale, and we found it very difficult to replace it by a more economical method of cultivation. It is partly due to the condition of the soil which is not, I think, generally applicable here, and the

problem there is not so acute as the population is very sparse and there is an almost unlimited amount of land available for this rather uneconomic kind of cultivation. Here we have a larger population and a limited area, and it is, I think, desirable that if anything can be done to encourage these people to make a more economic use of their holdings in the dry zone, it will not only be beneficial to them but it is also very desirable in the interests of the whole community. I am glad to observe that the experiments which Mr. Stockdale has been carrying on in investigating the possibilities of introducing some method of rotation of crops or some method of mixed farming on these chena lands, if not already a proved success, are at any rate encouraging and helpful. I think that if the hopes which are now entertained are realised, a very great deal will have been done to help those people who need our help most, that is the cultivators in the dry zone who are unable without some method of chenaing or something corresponding to it to produce enough food to keep themselves alive. If we could help them to produce food crops in rotation and make a really economic use of their holdings, we would have gone far towards solving the problem of the dry zone cultivator which is so very disheartening at first sight to anyone who travels through that area.

There is yet another sphere in which something can be done to help the cultivators and that is in the method of co-operation. I am a firm believer in co-operation. I have seen it work in many countries successfully. I have also seen failures, and I think failures so far as I have been able to form an opinion have been due either to one or two causes or to both together. One cause was undue dependance upon the Government which involves, of course, inadequate self-reliance, and the other was the operation of the particular Co-operative Societies over unduly large areas. Under these conditions it is impossible for the members to keep the operations of their own Societies under their own control. I hope in the light of experience gained elsewhere we shall not repeat those mistakes in Ceylon. We are in a sense making a new start, and we are fortunate in having the services of an enthusiast like Mr. Campbell to advise co-operators at this stage, but I have noticed that some of the views which he has expressed have not met with universal acceptance. There has been a good deal of discussion especially on the question of the rate of interest to be charged to co-operators borrowing from their Societies. I do not want to say anything much on the rate of interest. The general principle is quite easy. It is quite easy to say that the rate of interest charged should not be so low as to encourage improvident borrowing and it should not be so high as to check legitimate enterprise. That, of course, is perfectly easy, perfectly obvious and perfectly irrefutable a statement. But the difficulty comes

in when fixing the particular point at which the percentage conforms with these two requirements. I am not going to attempt to fix it here. No doubt, in considering where it should be fixed, we would be well advised not to overlook the experience of other countries—India and those European countries where co-operation has reached a very much higher stage of development than it has reached here. We should profit by the experience of others and not indulge over much in *a priori* theories. We must be guided by what has been found to be the case elsewhere and not condemn off-hand, at any rate, proposals which are based on the experience of other countries. I am not prepared to say whether the 12 per cent. rate of interest is too high or too low. It seems a high rate at first sight to anybody who has not studied the question, and in the light of experience elsewhere the rate should be 12 per cent. or lower is a matter that deserves very careful consideration. We are all anxious that Co-operative Societies should be of real help to cultivators and as such we ought to use every opportunity to establish them on a sound financial basis and we should not lead them into bankruptcy and involve their members in something like ruin as it has happened in other countries on occasions. I do not think I need say anything more about Co-operation except to stress once again how very important it is that the co-operative movement should be independent of any kind of spoon-feeding or subsidising by the Government, but that it should stand on its own feet; that it should inculcate habits of self-confidence among its members and that it should be a virile organism deriving strength from its own members and not from any outside source. I am confident that if from a mistaken sympathy—the sympathy which we all feel with the cultivators, but which may be mistaken in its application—we pamper or spoon-feed the societies at the start, we will not be helping them to produce that healthy growth which is necessary for their continued existence, and above all we will not be enabling them to inculcate among their members the true spirit of co-operation which is based upon self-help and not upon help from other quarters.

Now another matter which the Government has had under consideration during the past year have been proposals for the extension of the work of the Department of Agriculture with special reference to the giving of further assistance to the small grower. We have sanctioned further experimental stations, and we have made further provision for the distribution of agricultural literature and we have decided to establish agricultural schools for vocational training. We have made a start with two schools —one in the neighbourhood of Galle where the buildings are either completed or in course of completion. The other is in the North-Western Province, and I gather that the process of acquir-

ing the necessary land has been completed or is about to be completed. It should not be long before a beginning is made there also.

This brings me to my old friend, the question of agricultural bias in education. I never lose an opportunity of talking about it. I know that it is a platitude and a truism and that people get bored when they hear it mentioned. It is a matter of such importance, however obvious it may be, that it should be brought to the notice at every possible opportunity, so that it will not be overlooked. It is one of those things that it is very easy to pay lip-service to, but very difficult to carry out in practice, and therefore, unless we have it always before us, we may think that we have done our duty when we say that there should be an agricultural bias in education and that children in schools should be given an incentive to agriculture and leave at that. We have got to do a great deal more. The way to begin is by getting at the teachers. The difficulty is to train our teachers in such a way that they will not only be able to impart a certain amount of instruction in agriculture but that they will really be interested in agriculture, that they will look upon it in such a way that they will be doing their best if they will rather turn the children whom they teach into good agriculturists rather than indifferent clerks. It is most important that something should be done in the training of teachers. I am not sure how it is to be done, but I hope that a conference such as this will be able to make suggestions which the Government would gratefully accept and sympathetically consider. It is a very difficult question; I do not think we can solve it at this conference or even in the few years I shall spend in this country. I trust that some progress will be made, and although we may not achieve any practical results, we may, at any rate, get nearer to the determination of the right policy to be followed in practice. I might think I have done my duty if I went on annunciating that theory. We have got to find out some way to interest not only the children but more particularly the teachers in agricultural work.

There is another point which I think, strikes any new-comer to Ceylon, and that is the poor quality of cattle in the country. That again is a very difficult problem, and anybody who comes from other countries like Eastern or Central Africa, cannot expect to see the same type of healthy and well-fed animals that one finds there. I do feel that something more might be done than has been done in the past. The difficulty ought not to deter us from overcoming it. I know that Mr. Sturgess, the chief Veterinary Officer, is very anxious that this question should be dealt with in some manner, but naturally, he has not a patent remedy to remove all the difficulties confronting the problem. To solve the difficulty requires a great deal of thought, and I hope the Government will be able to undertake some of the experimental work and

give some help to the work already being done by Mr. Sturgess at the Government Dairy Farm and elsewhere. The improvement of stock is, I think, a matter of great importance to the whole country, not only from the point of view of the meat supply, which is not so important as Ceylon is not essentially a meat-eating country, but more particularly from the question of milk supply, and besides, cattle are an important factor in transport in this country, and in many parts of the country agriculture depends very largely on the manure produced by the cattle—I know that it is specially so in the North. Generally speaking, if something is done to improve the type of cattle in the country it is work well done. Again, I do not know how it can be done, but I am sure that more can be done in the future than has been done in the past. I hope shortly to see some of the experiments which are being carried out by Mr. R. M. Fernando in Kurunegala. It is probable that other people would be able to do equally good work in other parts of the country and a better strain of breed might be introduced into the cattle resources of our country.

Another point of transcendant importance almost to the small grower is the question of marketing. No doubt, it hangs together, to some extent, with the question of co-operation. I think there is at the present moment, great difficulty for the producer of these minor products to obtain a really fair price for his produce. There is no market to which he can take his goods and he must accept whatever price that is offered to him by any middleman who came along. The organization of markets is not a very easy matter, but it is certainly one that has to be considered. I am glad that the Director of Agriculture has had this question under consideration for some time. It is no use encouraging the small man to produce more than what he does to-day unless you make it possible for him to sell it at something like a reasonable profit.

I will not keep you any longer. We have a long agenda. You have not come here to listen to me. You have come here to impart information between yourselves. I look forward with great interest to some of the items on the agenda. One question of paramount importance is the question of soil erosion on which a paper will be read by Mr. Dias to-morrow. I have seen for myself the great work which is being done by Mr. Dias in his own estates in Kalutara. I think the problem is not mainly confined to the rubber industry. It is one that affects the tea industry even more vitally. If I have been correctly informed, soil erosion in the past from tea estates has been responsible not only for the loss to these estates of very valuable soil but also in some measure for the floods which have affected the Low-country owing to the silting up of some rivers. I do not know whether that is the case or not. If it is, it is clear

that it is the duty of planters to check erosion not only in their own interests but also out of consideration for their neighbours. I am confident that if such a duty is realised by them they will not be slow in endeavouring to remedy such evils as may exist, as far as they can be remedied. It is said sometimes that the evils can be remedied by means of cover crops and contour terracing. Others say that more skilful forking of the right kind will do a great deal to check washing away of the top soil. Others point out quite obviously that if you plant the tea bushes straight up the face of a hill, you will be doing all you can to encourage soil erosion. We cannot expect tea estates to replant all their bushes, but there may be other remedial measures which may have an important effect in reducing the amount of erosion. It is the duty of the planters and it is obviously in their own interests that they should study this question very carefully and that they should endeavour as far as they can to prevent the washing away of the soil which is of great value to them and which must at all events be conserved.

Another question of very great importance is to be raised and that is the last item on the agenda in the paper to be read by the Director of Agriculture himself which is on "The Economic Development of the Dry Zones of the Island with special reference to the work of the Department of Agriculture on the rotation of crops." I have already said something about this. It is a matter which is deserving of the closest attention by everybody. It is one which affects not only the agriculture but it is also intimately connected with the prosperity of the whole country. It is most essential that these unfortunate villagers who live in the Dry Zone should be helped and we should attempt to help them not by the giving of doles but by making it possible for them to earn a decent living from the land at their disposal. These experiments are directed to that end, and I am sure you will all agree with me in wishing the Director all success in his experiments.

Before I sit down there is one more thing which I want to touch upon very briefly, namely the forthcoming visit of Mr. Ormsby Gore. As you all know, he has taken for many years a special interest in research work of all kinds and he is especially interested in agriculture and agricultural research and he hopes during his visit here to see what is being done in this Island. We will show him as much as we can, and I hope he will be favourably impressed by all that he sees. But whether he is favourably impressed or not, I am sure of one thing and that is, that he will receive from all sections of the community a most cordial welcome.

His Excellency then called upon Mr. T. Petch, Director of the Tea Research Institute of Ceylon, to read his paper on "Some problems for the Tea Research Institute."

Some Problems for the Tea Research Institute.

T. PETCH, B.A., B.Sc.,

Director, Tea Research Institute.

IN the annual report of the Tea Research Institute for 1926, I made the remark that "the tea bush is the basis of the tea industry." That should be a truism, but it is one that has been in a great measure, one might say almost entirely, overlooked. It is recognised, of course, that one cannot have a tea estate without tea bushes, but beyond that the bush has received very little consideration.

One reviewer of that report seized on that remark, and declared that it ought to be turned into a slogan, printed on cards, and hung in a conspicuous position in the office of every tea estate. As the reviewer in question has been engaged on research work in tea for many years, we may deduce that the position in other countries is pretty much the same as in this. In fact, we know, from the books and articles published on tea cultivation, that it is so. There has been very little investigation of the healthy tea bush, nothing comparable with the investigations which have been carried out on the rubber tree.

Now, if you examine the reports of experiment stations which have been established for research on one product you will find that the modern tendency is to base the research largely on a study of the living plant. Stations dealing with fruit trees endeavour to find out the effect of pruning on the production of fruit, and what factors in the plant result in the formation of fruit buds and leaf buds respectively. Investigations on barley in England have centred on the changes which take place in the plant during its growth. And the researches carried out under the auspices of the British Empire Cotton Growing Corporation, an Association which might be expected to be interested only in the harvested crop, consist to a great extent of investigations into the physiology of the cotton plant.

It may be granted that in plant breeding one has actually got down to a study of the plant from one aspect, but it is now realised that more than that is required, and that it is necessary, if we are

to make the best use of our cultivated plants, that we should know how they carry on their life processes and what goes on inside them. Hitherto, in tropical countries, these processes have been explained in terms of general plant physiology. But there are two possible flaws in that. In the first place, plants do not all react alike to external factors, and in the second, ideas on plant physiology in general have been based on experiments made in temperate climates and may require modification in the tropics.

Even in temperate climates, investigations on certain parts of the plant have been strangely neglected. It is only recently, and chiefly in America, that investigations have been carried out on root development. In a recent number of *Nature*, a reviewer reviewing an American book on the root development of vegetable crops, writes as follows:—

"Constant endeavours to improve crop growth have led to the accumulation of a mass of information concerning the aerial parts of plants and the factors influencing their development. Our knowledge of the under-ground parts, whether roots or stems, has not increased at the same rate, largely owing to the mechanical problems which render investigation difficult and laborious. This is the more to be regretted, in that the environment of the root can to a large extent be controlled by cultivation and manuring, thus giving scope for the direct amelioration of growth conditions, whereas climatic and light factors, which directly affect the aerial parts, are beyond control by human agency."

As regards the roots of the tea bush I can find only one definite observation. That was recorded by a Ceylon planter, Mr. Oliver Collett, of Binoya. He stated, "In Ambegamuwa, I find that the rootlets die back in May and commence to grow in September; but my experiments in this direction are as yet far from being conclusive. It is curious that very little is known of this phenomenon up to the present time. Mr. Willis, of the Peradeniya gardens, tells me that no observations have been hitherto recorded in Ceylon regarding it, though he points out its great significance in connection with the question of manuring. It is, for example, obviously inadvisable to manure tea when its feeding rootlets are not in a proper condition to assimilate it."

It is nearly thirty years since that observation was made, but we do not know any more about the subject. Is the growth of tea roots periodic ? If it is, when are the periods of growth and how does the periodicity vary with the district. Collett's observation was made at Watawala, in a wet district. What happens in the drier districts ?

In temperate climates, the principal growth of new roots occurs in the spring. But investigations have been made chiefly on deciduous trees, whereas tea is an evergreen.

Current ideas of root growth in Ceylon have been brought from temperate countries. Moreover, they were brought a long time ago, at a time when people invented theories without soiling their hands with investigation, and they have long since been exploded in their country of origin.

One prevalent idea is that the roots of a plant extend outwards from the stem just as far as the branches do, so that the feeding rootlets will be found just where the rain water from the branches falls. It is a very old idea, but the man who originated it had not taken the trouble to uncover the roots of a tree. It is certainly not true of trees in Ceylon.

Another idea is that the root system of a plant is a reflection of the crown, just as you may see the reflection, in the water, of a tree growing on the margin of a lake. There is obviously no support for that idea, for the branching of a stem and the branching of a root depend on two different internal structural factors. But the idea cropped up quite recently in connection with a new system of handling young tea by making it branch at an early age. It was objected that if the plant was not allowed to run up, it would not develop a tap root. I do not know of any foundation for that view. Taking plants in general, the length of the tap root does not bear any necessary relation to the dimensions of the part above ground. I take it that it was merely a reflection of the reflection idea.

Another prevalent idea, firmly established in the tea districts of Ceylon and India, is that the roots of the tea bush die back when the bush is pruned. Here again, I am unable to find any recorded observations or experimental evidence in support of that view. It is quite possible that in temperate countries, when trees are pruned in the autumn, there may be a coincident death of the finer roots, due to the season, which would have occurred whether the trees had been pruned or not; but in spring or early summer pruning, there is no evidence of any die-back of the roots. It is highly desirable that this point should be investigated and definitely settled, because it, again, has a direct bearing upon our systems of manuring.

A recent book on the Root Development of Field Crops has summarised most of the available information regarding the growth of roots. As regards the effect of pruning on the growth of roots, it contains only one observation. That was made on peach trees, three years old, which had been trained up on different systems, some having been merely thinned out, while others had been thinned out and headed back severely. Eleven trees were dug up and their roots examined and weighed. The average weight of the tops and roots, taken separately, in the case of the trees severely pruned, was about one half that of the trees

lightly-pruned, while the spread of the roots of the lightly-pruned trees was about half as much again as the spread of the roots of the severely-pruned trees.

Unfortunately, no details of the experiment have been published. The original account is merely a paragraph in an annual report, and the data are insufficient for a conclusion. It might very well be that the diminished volume of the roots has to be attributed to a relatively smaller amount of food supplied by the more severely-pruned tops.

The question of root growth comes up again in connection with the operation of forking. I have gone round an estate in company with the Superintendent, shortly after it has been forked, and he has pointed to the masses of feeding rootlets broken off and brought to the surface, with the query whether that can really be good for the tea bush. Well, it would be easy to sympathise with him, and talk of barbarous treatment, but really I don't know. It is a matter for investigation and experiment. I doubt very much whether the destruction of those feeding rootlets does any harm, even though it might have a temporary effect on the crop. Of course, it is known that root pruning tends to make a tree produce fruit, but in forking there is nothing so drastic as root pruning. On the other hand, it is customary to fork in shrubberies in the autumn, in temperate climates, to break up the matted masses of roots; and in re-potting plants, one trims off the mass of rootlets which lines the pot. I am inclined to sympathise with the view which regards forking as equivalent to re-potting,—that the roots of adjacent tea bushes become too matted, and that the forking provides a necessary trimming back. But it is all a matter for investigation and experiment, and the investigation must be based on a study of the root growth of tea.

There are many other directions in which information on the root growth of tea would be useful,—for example, the question of interference between the roots of shade trees and cover crops and those of tea, the effect of weeds on tea, etc., but for the present it will suffice to have indicated how our lack of knowledge affects our ideas on manuring and cultivation.

Turning to the aerial parts of the tea bush,—the most important operation, and the one which most urgently demands investigation at the present time, is pruning. To quote again from my report for 1926, " the problems involved in pruning constitute easily the most serious feature of tea research in Ceylon and should receive the fullest possible attention."

Why do we prune ? The answer, of course, is to make the bush produce new shoots which will continue to flush for two years

or so. But beyond that we know nothing. Why does the bush stop flushing ? We don't know. If we did we might be able to make it run longer.

The only explanation of the effect of pruning tea that I have met with, is that the vessels which conduct the sap up the stem become partially obstructed by deposits, and consequently it is necessary to remove this clogged-up wood so that the sap may ascend more freely. But that statement is certainly incorrect. The vessels do not become obstructed by deposits. The explanation quoted appears to regard the stem as a sort of filter, which filters out particles of solid material taken in by the roots. But the roots cannot take in solid materials, and so there is nothing to filter out. Moreover, a little reflection will make it evident that, in pruning, one leaves the tap root and the oldest wood, both of which, on the theory in question, should be the parts most obstructed by deposits.

Before we can offer an explanation of pruning, we must know something about the transpiration of the tea bush, the rate at which water moves from the roots up the stem, the region in which the transpiration current moves, whether over the whole of the cross section of the stem, or only in the outer layers, and how the movement is affected by external conditions. This takes us back again to the roots, for it will include the phenomenon of root pressure and its variation with external factors. Given this knowledge, it might be possible to explain the occurrence of " die-backs " and to devise some method of avoiding them.

In some districts, it is customary to leave one branch unpruned, a live branch, to carry the bush on until the new shoots appear. This is said to be successful, but from general principles one would expect an increase in die-backs over the remainder of the bush, especially in dry whether.

When a tea bush is in plucking, the leaves manufacture starch, some which is utilised immediately in the production of new shoots, while the balance is stored in the stems and root, as reserve food. When one talks of reserve food, one means a carbohydrate, in this case starch.

After clean pruning, the new shoots which are produced are formed at the expense of the reserve food, starch, which is present in the bush at the time of pruning. The main bulk of the leaves, stems, and roots consists of cellulose, which is another carbohydrate and is made by the conversion of the starch. The nitrogen, phosphoric acid, and potash, supplied as manure, are principally of use, in so far as they enable the plant to utilise its reserve of starch. If the bush is clean pruned, without a leaf left on it, its new shoots can only be made from the reserve starch in the bush. It cannot make new shoots unless it has some reserve

starch. So if it has no reserve, it may be expected to die. It cannot make any more starch until it has acquired new leaves.

In general, when a bush is clean pruned, there will be a certain amount of reserve food in the bush. It is impossible to increase that amount by manuring at the time of pruning. As the new shoots develop, the stock of reserve food will diminish, and it cannot increase again until the new leaves are in working order and are manufacturing more starch than the bush is consuming.

The production of new shoots and the rapid healing of wounds depend upon the existence of a store of reserve food. The obvious suggestion, then, is that the bush should be treated before pruning in such a way that it may have an adequate reserve. The matter, however, is not quite so simple as it seems.

Investigations on growth and bud production in temperate climates have led to a theory that the behaviour of a plant, as regards vegetative growth and fruit formation, depends upon the ratio of the available carbohydrates in the plant to the available nitrogen. Briefly, if the available nitrogen is in excess compared with the available carbohydrate, there will be a vigorous vegetative growth. But if the available carbohydrate is in excess, as compared with the nitrogen, growth will slow down and the conditions will be favourable for the production of flowers and fruit.

From the point of view of the crop, we require of the tea bush, vigorous vegetative growth, that is, the available nitrogen should on this theory be in excess. But for the healing of wounds and the actual building material of the shoots, we require a large store of reserve carbhoydrate, which may mean that the bush will flower and fruit. The two requirements are therefore opposed to one another. If we treat the bushes in such a way that they will store up reserve starch, they may cease to flush. But before any definite statements can be made on this point, we require a thorough investigation of the process of formation of starch and sugars by the tea bush, both in its normal condition and as it is cultivated.

We have already obtained some information about the distribution of reserve food in the tea bush. But we require to know how much food the bush is able to store up during its period of plucking,—that is, what balance is left after the production of new leaves and shoots in the intervals between pluckings. We also require to know how soon, after unfolding, a leaf begins to manufacture carbohydrates, and what is the probability of any extensive storage of food between the first appearance of shoots after it would be possible to decide whether it is advisable to let the plucking, and the operation of tipping. Given that knowledge, it would be possible to decide whether it is advisable to let the bush run longer before tipping. We are told that the foundation of good wood is laid during recovery from pruning. But that is

a matter for investigation, and it cannot be settled by ex-cathedra statements. There are, at least, two factors concerned, the amount of food which is being manufactured by the new shoots, and the amount which was in the bush just after pruning. It is very probable that the latter is the more important.

The theory has been put forward that pruned tea is in the same condition as a young plant growing from a seed, because it has to put out an entire new leaf system. It has been overlooked that all deciduous trees have to put an entirely new leaf system every year, with the twigs necessary to bear those leaves, as woody plants cannot produce leaves without the simultaneous production of twigs. On the theory quoted, every tree would become equivalent to a seedling every year. It would appear more legitimate, as regards nutrition, to compare a pruned bush with a deciduous tree after wintering than with a seedling, though even in that case the comparison cannot be pushed very far.

I have brought forward this aspect of Tea Research, because it seems to me one of the most important, if not *the* most important, and there is a great danger that it will be overlooked, as it has been in the past. There is a considerable area of tea in Ceylon which is in a deplorable condition, largely because of its past treatment. Whether it can be made sound again requires much experiment. But it is imperative that we should undertake investigations which will, if possible, prevent the rest of our tea going the same way. It is alarming to see 12-year old tea in the low country getting into the same condition as old tea in mid-country. We must undertake investigations which will enable us to devise modifications of our methods of treating the tea bush so that it may live a more healthy life. We should aim at a more rational treatment of the bush, in accordance with its physiological processes, instead of dosing it with proprietary mixtures.

For these investigations we need a plant physiologist. At present we know nothing about the physiology of the tea bush, and are treating it haphazard, with results which are only too plain. Some of these results may be due to the adoption of practices from other countries. It is wrong to adopt, without investigation, practices from countries where the bushes are rested for several months each year. In my opinion, the Tea Research Institute will be committing the most serious blunder it can ever make, if it does not appoint a plant physiologist.

It has been objected that if a plant physiologist were appointed, it would be many years before he would obtain any results which would be of use in practice. That appears to me to be an argument in favour of making the appointment at the earliest possible date. However, I cannot agree with the statement, as in my opinion information on some points would be obtainable very quickly.

On the other hand, the diametrically opposite objection has been put forward,—that the plant physiologist would soon finish all the work I have alluded to, and would then have nothing else to do. I cannot agree with that either.

But supposing that it was necessary to find him other work, there is another botanical subject waiting, namely, the selection of tea seed bearers. Scientists in Java have taken up this question, just as they took up selection in rubber, and they have made considerable progress. That is too big a subject to be dealt with this morning, but I hope to summarise the available information at an early date in the *Tea Quarterly*.

There are, of course, many other problems which await the attention of the Institute. I have not touched on the chemical side, because there is no fear that that side will be overlooked. Indeed the danger is rather that, following the old disused track, the Institute will be over-chemicalised. And in this connection, I must mention one fallacy which is still current in Ceylon, namely, the belief that, from a chemical analysis of the soil, it is possible to decide what manure should be applied for the growth of any particular plant. That idea has been abandoned by soil chemists. On this point I quote Sir John Russell (Annual Reports on the Progress of Chemistry for 1921, p. 199). "One of the most difficult problems for the agricultural chemist is that of soil analysis. He is expected to analyse soils and on the basis of his results to give recommendations as to manuring. Unfortunately the problem is particularly difficult: in most cases insoluble on our present knowledge." In other words, it can't be done. I hope that the Board of the Institute will consult authorities on soil chemistry in England or America, before they embark on the futile business of analysing soils as a basis for advice on manuring.

Of course, one does meet with patches of soil which will not grow tea, and those are now being investigated by the Institute. But the chemical analysis of a soil on which tea is growing normally, as a basis for the composition of a manure mixture, is out of date.

Discussion.

His Excellency.—I think we are very much indebted to Mr. Petch for his paper. I do not propose to make any comments as, I am not competent to do so, but I trust that those who know more about this subject than I do will give us the benefit of their views. It would be well to have a general discussion on the paper first before we deal with the specific points raised by the Kandy District Planters' Association and the Morawak Korale Planters' Association.

Mr. H. A. Webb.—May I ask how it is possible to decide what sort of manure must be used?

Mr. Petch.—That is only possible by experiment. You will have to undertake a number of manurial experiments.

His Excellency.—It is purely empirical. You would have to set out manure experiments and make tests.

Mr. Robert de Zoysa.—One has to spend a large sum of money before he can find out the result. What is good for one soil may not be good for another soil.

Mr. Petch.—Naturally, but that would be money well spent.

Mr. Wace de Niese.—Stated that when they applied and sent samples to the different firms in Colombo that dealt with manures, they all got more or less the same mixtures. Surely there was some basis on which those manure firms worked. They could not do it at random nor would they do guess work. In all cases the mixtures were identical.

Mr. A. C. E. Wanigasekere enquired whether the sweeping condemnation of chemical analysis of soils made by Mr. Petch was justified.

Mr. Petch replied that he did not condemn it wholesale, but there were several points against it.

Mr. Wanigasekere asked whether it was not the fact that the chemical analysis of soils gave them some indication of the percentage of nitrogen, phosphoric acid and potash and also figures with regard to the availability of this plant food.

Mr. Petch.—It certainly gives you the amount in the soil, but does not give you the amount available for the bush which is an important point to be considered.

In reply to a further question by Mr. Wanigasekere, Mr. Petch said.—The idea at the present time is to get information by manurial experiments. It is granted that you may come across probably one case in ten thousand where you find your soil deficient in something, but that is the exceptional case.

Mr. Keiller stated that he would like to say that he was in entire agreement with Mr. Petch when he said that soil analysis was of little practical use. Those of them who had heard it said before would not be surprised to hear it now. It so happened that he (the speaker) did a great many analyses of soils, but he did not imagine that any of them were going to be of much practical use. He did most of those analyses because he was asked to do them. He always took the opportunity of discussing the subject with planters and dissuading them from the idea that soil analyses would indicate to them what manure should be put in. One could not, of course, explain that to every body, and he might say that he did a great many, useless soil analyses. He would say that obviously it was to his interest to do those soil analyses and to make out that they were very useful, but he knew well that such was not possible. He thought perhaps that that would be clearer, if he pointed out that, as Mr. Petch stated, there were limitations in soil chemistry, and the fundamental limitation in that question was the difficulty of knowing how to treat the soil samples to begin with. The old idea of soil analysis was based on dissolving everything of the soil that was possible. The soil was mixed with strong acid and boiled for many days and the resultant solution analysed. He would like them to realize that that could not be done. The limitations of soil chemistry did not come into that part of the proceeding. But the difficulty arose in deciding how they were going to make the solution. They could dissolve their soil in strong acids and extract everything they could, but it was soon realized that such an extract did not bear any relationship to what was actually in the soil. Then they went to the other extreme and dissolved the soil in water, but that too did not give any good results either. It was not merely a

question of the analysis of the soil, but it was rather a question of the treatment of soil before analysis.

Continuing Mr. Keiller offered a few remarks generally. It was stated that when you prune a tea bush and remove a great deal of wood, there was die-back of the roots. He tried to get information on this point but could not find anybody who was prepared to admit that there was die-back. He thought they must be careful in making any statement on that point. It was generally agreed that there was a cessation of root activity when the bushes were pruned, but that there was actual die-back no one was prepared to admit.

Next the speaker referred to the question of defeathering, and to the time of the application of manures. Regarding the latter he stated that the time of manuring was very important as it had much to do with the efficiency of the tea bush especially in a country like Ceylon. He would, as a matter of generalisation, state that one should avoid applying general mixtures during weather when the growth of tea is dormant. Those manures would be effective at a time when the conditions were suitable. On the question of forking, he agreed with Mr. Petch. Then about the breaking of roots, they ought not to make too much fuss about it. The experience of agriculturists in every part of the world was that they could not get their best crops if they did not cultivate their soil in the sense of tilling it. If they destroyed roots in tea what did it matter? The balance was very much in favour of improved cultivation. The whole thing was a compromise, and it was impossible to lay down hard and fast rules.

Continuing Mr. Keiller said that the suggestion was often made that it was better to have the tea in what was commonly called a "good heart" at the time of pruning rather than attempting to get it into condition after it was pruned. There was a good deal to be said on both sides. Tea in "good heart" seemed to be having an appearance of vigour, but when the bush was pruned, they would be pruning away a great deal of the reserve food. A young plant before leaves were put out and before it could establish its independence had to depend upon the reserve material in the wood.

Mr. Wanigasekere asked whether it would not be advisable to apply a pruning mixture while assimilation was taking place.

Mr. Petch stated that the point he made was that when the bush was pruned it could not make use of food manufactured in the leaves, and it had to live on the reserve in the bush. The only effective way to have more reserve was to put in the manure 6 weeks or 2 months before pruning, and he thought that that had been done in many cases successfully. The objection of the Superintendent was that he could not manure until the bushes had been pruned, but the V.A. now usually overruled that objection.

Mr. R. G. Coombe stated that certain estates had introduced a new method with regard to pruning. A number of side branches were left unpruned with their leaves intact. He brought up that matter at the last meeting of the Estate Products Committee; he would like to know from Mr. Petch whether that method is a desirable one or not.

Mr. Petch said that they should get down to something lighter in pruning. If they left leaves on the bush after pruning the bush would go on manufacturing its food. They ought to adopt some system of pruning which would leave some leaves.

Mr. Stockdale said that Mr. Petch might elaborate his reasons for stating that when individual branches are left unpruned there was a liability to die-back. In Uva and other dry districts the method had been found to be most successful.

MR. PETCH.—It is done in dry districts. In Uva die-backs are particularly bad. If the drought is very severe your branch left unpruned has difficulty in drawing up the water from the soil, and it draws moisture from the other branches, and causes an increase in die-backs. Of course, it entirely depends on the extent of the drought.

MR. STOCKDALE stated that he did not consider the droughts severe enough to cause the unpruned branch of tea to draw upon the moisture in the pruned branches. Tea was too deep rooted for that to occur.

MR. PETCH replied that die-backs in Uva might be attributed to the fact that that district is pruned in dry weather.

MR. HORSFALL stated that he had done a good deal of work in that connection. His original trials were in 1921 on a very small area. He left leaves on practically every side branch. He was so pleased with the results that in 1924 he took on two fields more—a matter of some thirty acres, and in 1925 he extended the area. The results were most encouraging. The side branches further produced a spread of the bushes and thus prevented soil erosion, which was a more important matter. By this method of pruning he obtained a complete cover over the soil. He was quite pleased with the experiments he had conducted and fields so treated came in for tipping very much earlier.

HIS EXCELLENCY at this stage suggested that they might take up the points raised by the Kandy District Planters' Association and the Morawak Korale Planters' Association.

Branch Canker (Wood Rot) and its connection with Season of Pruning, Style of Pruning, and Shot-hole Borer infection.

MR. GORDON PYPER.—I have been asked to introduce this subject by my Chairman who is unable to be present. We wish to open a full discussion on the question of Branch canker. This matter has come into prominence a good deal during the last few years, but the disease has been with us probably for the last thirty years working its way very far, and we like to know if there is any information as to how this Branch canker developed. Is it a disease or has it been caused by the wrong treatment of bushes or of soil? When I came out to Ceylon in 1900, the system of pruning was rather a light pruning. Then later on there was a more severe type of pruning started and everything on the bush except the main branches were removed. This was done with the idea of preventing the growth of knotty wood. The style of pruning developed to be very severe in many cases, because one could see large acreages capable of producing 1,000 lbs. an acre with bushes cut down to 14 inches. The idea was to form a small bush and get as much as possible out of it. We wonder whether that has had anything to do with the spread of Branch canker. In 1905 I remember when I first took charge of an estate I wrote to my firm about this matter and they referred it to the proprietors at home. The proprietors, however, did not seem to worry very much about it, and rejected the suggestion made by me that artificial manure should be used. They seemed to appreciate the keenness of the young *Peria Dorai*, but they were not too anxious to adopt the suggestions made by him. Matters went on like that until 1911 when there was a good deal of heavy pruning done. But now again we seem to have gone back to the old-fashioned idea of light pruning. I wonder whether heavy pruning had anything to do with Branch canker. It has undoubtedly been with us for the last 30 years, but it was during the past 3 or 4 years that attention

has been focussed on it. The next point on which the Kandy District Planters' Association wants information is with regard to the seasons of pruning. There are different shades of opinion on that point. There are some who favour pruning in wet weather, while there are others who advocate pruning in dry weather, and dry weather only. That is a point on which a definite pronouncement would be most useful, and that is the reason why it is brought up by the Association to which I belong. There are others who are of the opinion that pruning should be done when the bush is at its lowest vitality. I understand that it is at its lowest vitality after two or three years in plucking, and probably in dry weather. I am sure that some definite information on this point would be most helpful. With regard to the question of the style of pruning, I know that there are different styles, and perhaps some information on that point would be forthcoming. There is also the question of shot-hole borer infection. Shot-hole borer had been with them for the past twenty-seven or twenty-eight years. He would like to know whether shot-hole borer had been the cause of die-back in tea. That was a matter that had come into prominence during the past three years although it had been with them for a very considerable time. He was sure that any information on those points that would be available would be gratefully received by his Association.

His Excellency said that Mr. Pyper had raised some very important points on which he hoped there would be a useful discussion. Personally, he did not propose to reply to any of them but he would assure them that he would follow the discussion with great interest.

Mr. Stockdale.—With regard to the points raised by the Kandy District Planters' Association, Dr. Gadd of the Tea Research Institute has sent in some notes. Unfortunately, Dr. Gadd is not able to be present at the Conference, but I would ask Mr. Petch to read to the meeting the notes sent in by Dr. Gadd.

At this stage Mr. Petch read out the notes of Dr. Gadd.

Branch Canker.

The subject put down for discussion at this Conference by the Kandy District P.A., viz. Branch Canker (Wood rot) and its connection with season of pruning, style of pruning and shot-hole borer infection, is one to which the Tea Research Institute is devoting attention. As yet, it has been impossible to collect the necessary experimental data on which definite statements can be made. Observational data are abundant, but it would be exceedingly unwise to attempt to draw any far-reaching conclusion from them alone. For one reason, wood-rot or Branch Canker has usually reached a fairly advanced stage, *i.e.*, it is often several years old, before attention is attracted to it. One cannot be certain, without microscopic examination, that branch canker has started until the wood is visibly decayed. The fungus responsible for the decay has then been active for several months at least.

It is, therefore, practically impossible to determine with any accuracy the time at which the fungus responsible for any branch canker lesion began operations. It may have been at pruning time or 3, 6, or any other number of months after pruning. Without accurate knowledge of the actual time of infection and the conditions operating at the time, it seems inadvisable to draw conclusions concerning the effect of environmental conditions on the incidence of the disease.

A study of wood-rot or Branch Canker in tea has disclosed a number of facts.—viz :—

(1) The diseased condition is caused by fungi which invade and decompose the woody portions of the bush.

(2) Any region in which the wood is exposed is liable to infection and remains liable until protected efficiently.

(3) Pruning cuts form the main points of entry for the wood-rotting fungi.

(4) A large wound is more liable to infection than a small one.

(5) A callus or mass of tissue, which develops from the cambium and cortex at the edge and ultimately covers the wound, forms the most efficient protection against invasion by wood-rotting fungi.

(6) A wound made by cutting a stem across heals less rapidly than a wound made by trimming off a stem flush with the parent branch.

(7) Callus formation does not stop the progress of a wood-rot which started before the callus cover was complete.

It has been suggested elsewhere, that branch cankers originate as sun cracks or sun burns. When a bush is pruned, the sun's rays strike the stems, which previously have been protected by the foliage. This is said to cause burns or cracks in the cortex which prepare the way for invasion by wood-rotting fungi. If such were the origin of branch cankers, the time of pruning would become of considerable importance, as pruning would best be done at times when the sun is likely to do least damage.

If branch cankers originate in this manner, it would be a simple matter to find sun cracks or burns on horizontal tea branches soon after pruning during bright weather. Also, areas from which the dead bark has peeled and so exposed unrotted wood should also be prevalent and easily found. Such symptoms, however, are not to be found on tea bushes in Ceylon, and one must conclude that there is little or no evidence to support the suggestion that branch cankers originate in this way.

I have described elsewhere the origin of branch cankers in Ceylon. Briefly, it is this. A wood-rotting fungus gains entrance at a wound, usually at a pruning cut. In vertical branches the rot works vertically downwards through the central core, and there is no external symptom of this decay other than the cavity at the cut surface. In horizontal branches, the rot approaches the upper surface of the branch, the cortex dies as a result, and the characteristic cavity or canker becomes exposed. Typical branch cankers, such as are normally found on horizontal tea branches, therefore, are caused by a wood-rot which progresses from the interior of the stem outwards and not through sun damaged bark, inwards.

Unless it can be shown that infection takes place only at pruning time and then only when weather conditions are favourable, there appears no *prima facie* evidence why the season of pruning should have any effect on the incidence of this disease. The evidence at present points strongly to the fact that a wound is liable to infection from the time it is made until it is satisfactorily protected. As the natural protection, the heal or callus, takes years to cover the wound completely, the actual time at which the wound is made becomes of relatively small importance.

In some districts, the time of pruning appears to be based on economic reasons rather than physiological grounds. Pruning should of course be done at a time favourable to the quick recovery of the bushes. Callus formation, or healing, is a growth phenomenon and, consequently, is a reflection of the general health and vigor of the bush. It is therefore dependent upon the many interacting factors which together promote health, and it is unlikely to be markedly affected by one factor, such as the time of pruning, alone.

The type of pruning has a direct bearing on the incidence of wood-rot. If hard pruning is practised, the wounds are large and open to infection for longer periods. Consequently, they rarely escape infection.

When once the rot has started the value of any callus formed later is diminished. The wood continues to rot below the callus and the heal rarely becomes complete. It is quite common to see a callus growth turning downwards into a large rotted cavity, in what would appear to be a futile attempt to overtake the rot—an impossible proposition.

Light pruning is to be preferred so far as this disease is concerned. Large wounds should be avoided as far as possible; if and when necessary, such wounds should be protected with an artificial antiseptic cover.

It appears to be a very common practice on many estates, when removing branches from a tea bush, to cut them out obliquely, leaving a short snag or peg attached to the parent branch. This appears to be an unsound procedure. If a branch is to be removed, it should be trimmed off flush with the parent branch. In the latter case, the wound heals more rapidly. Where snags are left, healing is never complete. The callus may start from the lower edge of the oblique cut, but rot sets in and the snag dies before the healing is complete.

Whatever style of pruning is used the cuts should be smooth and clean. Rough or broken surfaces will favour infection, because they more readily retain water and fungus spores. It appears very unlikely, at present, that this disease can be prevented entirely by careful pruning.

As regards shot-hole borer infection in its relationship to wood-rot its importance is not so great as was generally suspected at one time. It is well known that the shot-hole borer beetle introduces into its gallery a fungus which it cultivates and crops for food. The wood surrounding the gallery is frequently stained, but there is no evidence whatever that the fungus can initiate a rot of the wood. The evidence is against such a conclusion. Where the tea is vigorous, shot-hole borer galleries heal very readily. It has been estimated from experimental data that, on an average, a shot-hole gallery may be healed 3 to 4 months after the boring of the gallery is commenced, *i.e.* shortly after the beetles emerge. General observations indicate that wood-rot very rarely starts from an old shot-hole gallery.

If the bored branch breaks across at a gallery, the story is somewhat different. The broken branch then becomes for all practical purposes a pruned branch except that the broken surface is not smooth. The wood exposed at the fracture is as liable to infection by wood-rotting fungi as is the wood of pruned branches, and the risk increases with the size of the branch. The branches broken in this way are rarely very large, and usually they are pruned out before the fungus has done serious damage. Speaking generally, the part played by the shot-hole borer beetle in rendering the tea bush liable to infection by wood-rotting fungi is very small compared with that of normal pruning operations.

His Excellency.—We will now proceed to the points raised by the Morawaka Planters' Association: (a) Shade trees suitable for elevations of 1500-3000 feet, (b) Fuel trees for elevations of 1500 feet, (c) The relationship, if any, between Boga medeloa and prevalence of shot-hole borer. Is any representative from the Morawak Korale Planters' Association, present to open the discussion.

Mr. Stockdale.—In the absence of a representative from the Morawak Korale Planters' Association, I will just briefly deal with the first two points and leave the last one to Mr. Jepson to deal with later on. With regard to

shade trees suitable for elevations of from 1500 to 3000 feet, I understand that in the Morawak Korale there has been a certain amount of difficulty with Albizzia which formerly was used in tea cultivations, and planters are looking round for other shade trees to take the place of Albizzias. Of course, the shade trees that we know on this side could all be recommended for trial in the Morawak Korale—shade trees such as Gliricidia, Dadap and *Albizzia stipulata*, etc. With regard to the more recently introduced ones, I would mention *Derris robusta* and *Dalbergia Assamica* which are commonly grown in Assam and Northern India, and as far as I can see, are very promising and worthy of experiment by all estates interested in the subject of shade trees in Ceylon. At present one cannot definitely say to what elevations they would be suitable, but within the limits indicated in the points raised by the Morawak Korale Planters' Association, I think these trees could be recommended for experiment. We also have growing in the Royal Botanic Gardens another tree to which I would like to direct attention. It is *Derris dalbergioides*. It seems to me that it is a tree well worth trial by those estates that are looking for new shade trees. I am firmly convinced that it is the duty of all estates to make trials with a number of shade trees and not depend on one only. In this connection, I would like to mention that one should not also overlook the value of Grevillea to the tea industry. In the past that tree has been used in the dry districts but in recent years it has been extended to the wetter side and to the low country. I think it should be tried in those districts where dadaps will not grow. It is a tree well worthy of consideration. It is deep rooting and gives a very large fall of leaves..

With regard to the fuel question, I would rather leave that to a representative of the Forest Department.—Mr. Sargent is here and I think he will deal with that part of the question. I have noted down a few trees that might be recommended, but I would prefer to leave the matter for the present to Mr. Sargent.

Mr. Sargent said he regretted that he had not had longer notice on the subject as he could then have made investigations with a view to getting as much information on the subject as was possible. He had an excellent officer at Matara who was very familiar with the Morawak Korale, but unfortunately, the Department lost that officer and with him all the information that was gathered on the subject. With regard to the question of fuel trees for elevations of 1500 feet, he would like to say that the Forest Department had no plantations at all at that altitude, and it was impossible to recommend any trees without trial. The aim and object of forestry was first and foremost the preservation of soil, and at the present moment they were asked to recommend species for fuel plantations in areas in which the soil had been eroded for several years. It was not an easy matter at all. In their own work they endeavoured to avoid clean felling as far as possible. The only species which they had experimented on any extensive scale in that zone was jak. The Forest Department had considerable plantations of that kind and their own experience showed that although they could germinate the jak very easily in the first year after clearing and burning, it was a very different matter when they came to fill up the vacancies in the 2nd or 3rd year. There were, however, two species which would serve the purpose of shade trees and fuel. The first was *Cassia siamea* the Wâ which was to be found in the Kegalle district, and which was a leguminous plant. The other was *Filicium decipiens*—the Pihimbiya. He was of opinion that both trees were worthy of trial. There was one colony in Africa, the name of which he forgot, that secured considerable quantities of seed of *Cassia siamea* for fuel plantations. That tree was planted in the Ratnapura Dis-

trict in one estate and he (the speaker) thought that it was giving very good results. The rainfall at Ratnapura, he thought, was equal to that at Deniyaya. The Forest Department had not been consulted in the matter of fuel trees, and it was probable that the estates themselves or their managers knew far more about the species suitable than his Department.

In conclusion, Mr. Sargent stated that His Excellency the Governor had very kindly given him permission to attend the Imperial Conference on Forestry to be held shortly in Australia. He would be very glad to bring back any information he could gather on the subject.

MR. STOCKDALE.—There is one point on which I would like to ask Mr. Sargent a question. What about the possibilities of Sapu in that area?

MR. SARGENT.—It is a difficult species to grow. If you can get a start with it, it is alright.

HIS EXCELLENCY THE GOVERNOR.—I will now ask Mr. Jepson to give us information on the third point which is as follows :—"The relationship, if any, between Boga medeloa and the prevalence of shot-hole borer."

MR. JEPSON stated that he had no recent information on this point as questions relating to Shot-hole Borer had, for some time, been referred to the Tea Research Institute, and he had hoped that Mr. Light would have been present to answer this question. From his own experience of this pest, however, he knew that *Boga medeloa* was sometimes subject to severe attack by Shot-hole Borer but he did not think that it was preferred by this pest as a host-plant to tea nor that the interplanting of Boga medeloa with tea would lead to any serious increase in Shot-hole Borer prevalence, which he presumed was the main point in the question regarding which an opinion was desired.

HIS EXCELLENCY THE GOVERNOR asked Mr. Petch if he had anything to say on the subject.

MR. PETCH stated that he had no definite information on the subject except that Boga medeloa could be attacked by shot-hole borer.

MR. STOCKDALE.—In regard to the relationship between Boga medeloa and prevalence of Shot-hole Borer (c), which must not be lost sight of is the age of the Boga. This question has been under consideration with regard to various fungus diseases. It is conceivable that the older the Boga medeloa the more it is liable to be attacked by shot-hole borer. That is one of the chief points that one should not overlook in this question.

The discussion on the subject was then brought to a close.

MR. R. G. COOMBE said that, with the permission of the meeting, he would like to bring up a few matters in connection with the Tea Research Institute. He said that for some time past there had been comments in regard to what the Tea Research Institute was doing. That was a point he wished to answer. A good many of them were aware that the Institute was labouring under a great disadvantage in not having a home of their own. The Institute was at present in its third year of work, but so far, it had not been able to obtain an estate on which the scientific officers could reside and carry out the many and important investigations necessary, in connection with the tea industry. That was a very great disadvantage to work under and he was sure they would all appreciate it. Up in Nuwara Eliya the Institute was doing its best. That morning Mr. Petch had given them an indication of some of the problems which were being studied at the Tea Research Institute, and particularly some of the problems which he wished to have studied. He (the speaker) would ask the members of the planting community to bear with them a little longer until the Institute was able to obtain a home. Mr. Petch had told them that morning that it was most

important that they should have a Plant Physiologist. He had stressed that point in the paper read to them. He (the speaker) agreed with Mr. Petch, but where were they going to put him up? In his opinion it was not possible or expedient to enlarge the staff of the Institute at present. That was his considered opinion. Another point made against the Institute was that the public had not heard enough of the work done by the Institute. They had heard something of the work done by the Institute in the paper by Dr. Gadd which had been read to them, and which he was sure had been listened to with interest. The question had been considered by the Board of Management as to whether an annual meeting of the Tea Research Institute should not be held. The Board had considered that question, and it was decided to hold a meeting in conjunction with the Committee Meeting of the Planters' Association of Ceylon to be held in July, at which the work by the Institute would, as far as possible, be reviewed. Many problems were being considered at the present moment, and he (the speaker) thought that Mr. Petch would agree with him when he said that not many of them had reached the stage for publication. As soon as the Institute obtained a home of its own, it was the intention of the Board of Management to hold a conference similar to the one they were holding that day, but it would be confined to matters relating to tea.

His Excellency the Governor in winding up the discussion said that they had a very interesting discussion on an important subject. They were much indebted to Mr. Petch and Dr. Gadd for their contributions to the discussion. He listened with very great interest to the remarks made by Mr. Coombe. He agreed that research work should be carried on in an effective manner. In fact, he thought that it should be carried on in the most effective manner possible. As far as the Government was concerned, nothing would give it greater pleasure than to learn that the efforts of the Tea Research Institute to find a suitable home were successful. If it was in the power of Government to help in the matter, that help would be given most gladly. But it was a matter primarily for the planting industry. He would appeal to all large companies owning suitable property in the Island to help in the matter and do what they could in the interests not only of the industry but in the interest of the Island as a whole. He agreed that it was necessary to have a plant physiologist, but he understood that it was not the intention of the Board to enlarge the staff until a suitable Home was obtained. He hoped that a suitable home would be found in the near future and that the Institute would start the work that was necessary.

The Conference then adjourned till 2 p.m.

Monday, May 7, Afternoon Session.
2 p.m. to 4-30 p.m.

Discussion: The Uda Hewaheta District Planters' Association.—"The relationship between manuring and callus formation in tea."

The discussion was led by Mr. P. A. Keiller.

Having been called by His Excellency the Governor to lead the discussion, Mr. Keiller said.—This question of the healing of pruning cuts and wounds in the tea bush which is to be discussed this afternoon is one of considerable interest to everybody connected with the tea industry.

A good many of the points to which I wish to refer this afternoon have been dealt with in some respect this morning and I would be going over the same ground again, but I did not know at the time I wrote these notes what Mr. Petch had to say.

The Relationship Between Manuring and Callus Formation in Tea.

P. A. KEILLER, F.I.C.

THIS question of the healing of pruning cuts and wounds in the tea bush which is to be discussed this afternoon is one of considerable interest and, I think, importance, for the tea bush is pruned more often and more drastically I suppose, than any other plant of economic importance except, possibly, cinnamon, and many of the troubles from which the tea bush suffers are the result, either direct or indirect, of the exposure of cut surfaces by pruning.

In the normal course of events, when a branch is pruned off a tree, the cut end protects itself by growing a layer of callus tissue from the edges of the cut towards the centre, and this callus growth eventually covers the entire cut surface so completely that in time almost all external evidence of the injury disappears. This is not peculiar to trees growing in temperate climates, but occurs also in Ceylon, and can be seen taking place on almost any roadside tree from which branches have been trimmed. It can generally be easily seen on rubber trees also, which seem to be particularly active in growing callus tissue. It does not, however, readily take place in the case of tea, or at least it was very uncommon a matter of ten years ago, or less, although it is not such an unusual phenomenon nowadays.

Observations many years ago led me to suspect that this inability of the tea bush to grow callus over wounds was due to gradual weakening of the bush by continued plucking and pruning, which had resulted in a condition of carbohydrate starvation. It seemed to me that the continued recovery from pruning which the bush is called upon to make must involve a heavy drain on the reserve manufactured materials (starches, etc.) which are made in the leaves and stored in the older tissues of the wood, and that the replacement of these must be much interfered with by continual plucking.

It is during recovery from pruning, when the new buds and shoots are being put out, that the greatest drain on these starch (or carbohydrate) reserves takes place, and no replacement of them is possible until the new leaves begin to function, for they are made in the leaves; and obviously no large replacement can

take place without a large number of leaves. As soon as the bushes put on a moderate number of leaves, however, they are tipped, and most of the young and active leaves are removed. This process of leaf removal goes on constantly as plucking proceeds, and it seems obvious that the process of carbohydrate formation is greatly interfered with. The act of plucking causes many new leaf-buds to appear and these new leaves are also put out and developed largely at the expense of reserve food material, so that a constant drain on this reserve goes on from one pruning to the next. This constant depletion of starch reserves must, it seems to me, make the recovery from pruning more difficult each time and make also the new wood which is put out less and less good, and this I think is what has actually been happening in the case of most tea in Ceylon during the last 20 years or more.

As callus growth is closely connected with wood growth, and is in fact a modified type of wood growth, it seemed to me likely that poorer wood after pruning meant less ability to grow callus tissue over pruning cuts, and explained why such callus growth was so exceptional.

The result of this line of thought was the idea that anything which could be done to increase active growth in the tea bush during the only time when it is not plucked, namely between pruning and tipping, would help the replacement of carbohydrate reserves and so promote better wood growth and better healing, and this led me finally to advocate the application of nitrogenous manuring at pruning time.

I may say that it was many years before these ideas made any headway, and it was not until comparatively recently that continued trials on an estate scale were possible. These trials soon indicated that this type of manuring did induce the growth of callus on pruning cuts, and even on extensive wounds in the condition commonly known as cankered, and I was encouraged to continue the treatment.

Among other observations, I noticed that where a cut surface became encircled by a ring of actively growing callus, the central wood did not decay. This occurrence was evident even on large cut surfaces, although as had frequently been pointed out to me they take many years before the surface is completely covered. So long, however, as the ring of callus remains alive and healthy, the central wood does not appear to decay. The surface layer may, and in fact does, die and become disintegrated by ordinary weathering agencies, but there is not the same tendency to decay downwards and form a deep cavity as so often happens when no callus growth occurs. The explanation of this was not clear to me at the time, except that it seemed that the activity of the cambium was a factor in determining whether decay would take place or not.

A possible explanation has since been offered by the work recently done by Swarbrick at the Research Station, Long Ashton, Bristol, and a short account of his investigations will, I think, be of interest. The work started with an investigation into the best time of year at which to prune trees at Home from the point of view of their recovery from the injury, and for this purpose trees were pruned every month of the year, and a pruned end from each monthly pruning was examined at monthly intervals.

It was found that at some stage after pruning, varying with the season, the starch in the wood below the pruning cut disappeared and was replaced by a substance to which the name of "wound gum" has been given. Swarbrick as a matter of fact mentions two substances, but for the purpose of this discussion it will be sufficient to deal only with what he describes as wound gum. This material is of unknown chemical nature, and does not react as a true gum or a true resin. It is extremely resistent to chemical action, and the name wound gum is quite a convenient one.

I should like to emphasise here that this material must not be confused with the gum or resin which exudes from many trees when they are wounded. Its formation has nothing whatever to do with the external appearance of gum or resin, and takes place in cases of trees which have no tendency to resin exudation. It is called wound gum meantime merely for the sake of calling it something.

This substance forms in the cells which were previously filled with starch, and it seems probable that it is formed from the starch, and it gradually forms a series of plugs which eventually completely block the cross section and forms a barrier from one edge to the other. This barrier is only visible under a microscope.

During this series of observation it was found that this blocking by wound gum took place very slowly and incompletely when the growth of the trees was dormant, as in Winter, but that when branches were pruned in the Spring and Summer months, when growth was active the exposed ends became plugged in about 10 days and completely blocked in about four or five weeks.

It was also found that in no cases were the hyphae of fungi seem to penetrate the blocked region, they always stopped just short of it, and this seems to me a matter of great importance with reference to the decay of the wood in our tea bushes.

Subsequent to the formation of wound gum, the growth of callus at the edges of the cut surface begins and, in the normal course of events, eventually covers the cut. It is, however, in

these cases more in the nature of external evidence that internal blocking has taken place than the only protection which the wounds can produce.

The blocking is found to take place just below the cut surface and to follow a curved line which is deepest in the pith in the centre and closest to the surface at the edges, and it has been found that the cells immediately below the cut surface, although damaged by the act of pruning, remain full of starch indefinitely, and are not active in the formation of wound gum.

This is briefly the story of Swarbrick's investigation published in March, 1926, and its practical application amounts to this, that when growth is vigorous after pruning, the pruned cut is blocked by wound gum in such a way that micro-organisms and disease germs in general are prevented from penetrating below the blocked layer, but that when growth after pruning is slow, the blocking is slow and incomplete and the pruned end is open to infection at least until vigorous growth begins. It is also indicated that an abundant supply of starch is necessary for the blocking by wound gum to take place. These conclusions, if true in the case of tea, seem to me to justify the application of such manures at pruning time as are best calculated to promote vigorous growth immediately thereafter and that the maintenance of a good supply of starch is necessary. It is also clear, if we assume these physiological changes to take place in tea, why the continued depletion of starch reserves resulting in poorer wood after each pruning also lessens the chance of the cut being sealed by wound gum and leaves the exposed surface open to decay, while an explanation is also given why a cut surface once encircled by a callus tissue, does not decay although still exposed in the centre. It has been presumably blocked by wound gum before the callus growth appears.

I propose now to give you a very short account of my endeavours to find whether a similar series of happenings take place when the tea bush is pruned.

I might say, to begin with, that there is no inherent improbability that the healing process in tea or in any similar bush or tree in the tropics should not be the same as in temperate climates. I do not say that it necessarily is the same, but I see no reason why it should necessarily be assumed to be different. The various stages of the healing process described by Swarbrick are physiological changes which are affected in degree only, but not in type, by the seasonal changes which occur at Home, and it seems to me more likely than not that they follow the same course in Ceylon, at least in the case of Dicotyledenous trees, although they are doubtless equally influenced by seasonal changes, especially as it is a fact of common observance that such trees in all parts of the Island do form a callus covering over pruning cuts.

A convenient preliminary method of showing whether any obstruction such as that produced by wound gum forms in a cut branch is to remove a few inches of the cut end and to endeavour by means of a suction pump to draw a coloured solution through the specimen. I have applied this method to a great many such pruned branches in tea, and I have found clear evidence that in certain cases something occurs just below the cut end which prevents the solution of dye being drawn through. I have not had time to investigate a complete series such as was done at Home, but I have examined a large number of specimens at different stages from pruning and have found that more or less blocking takes place in a manner similar to Swarbrick's description. The specimens have been from various estates, some of them highly cultivated and some of them not, and I propose to hand round a few of them for your inspection. These specimens refer only to the preliminary investigation of the penetration of colour solutions, and while, partly through lack of time and partly through lack of the necessary section-cutting apparatus, I have not been able to make anything approaching a complete microscopic examination, I have with the help of my assistant, Mr. T. K. Anderson, to whom I am indebted for much of this microscopic work, examined a great number of sections, and I have found changes in the cell contents which appear to be precisely as described by Swarbrick.

To begin with, in every specimen examined, the cells immediately below the cut are full of starch. It remains as a thin layer below the cut to a depth varying from 1 c.m. to 2 c.m. but gradually disappears, and its place is taken by what is at first a pale yellow substance but which darkens gradually to a dark brown or black. This is the description of the beginning of the formation of wound gum by Swarbrick. These blocked cells increase in number as the time from pruning lengthens, and there is reason to suppose that they eventually extend across the whole of the tissue. Owing to the difficulty of getting a complete longitudinal section without a suitable microtome, I have not been able to obtain a specimen showing complete blocking, but it seems to me unlikely that blocking should begin, and proceed exactly as described by Swarbrick, and not go to completion, while there is also the evidence of the suction method that it does go to completion.

In one series of observations, a tea bush was pruned after a run of about 18 months, and specimens of the pruned wood were examined at different intervals. The following are some of the observations made.

1st day.—Starch abundant in all tissues.

4th day.—No trace of starch to a depth of $1\frac{1}{4}$ inches except in a thin band immediately below the cut. Cells turning yellowish brown.

5th day.—Starch immediately below pruned surface in a thin band not more than 2 mm. thick. No starch in any tissue except the pith up to a depth of 1 inch where it occurs in the pith, medullary rays and zylem, in this order. Starch less than 4th day, taken all over. Cells on edge of pruning cut turning yellow.

7th day.—Starch present in all tissues immediately below pruning cut. Present in pith in fair amount to about 2 c.m. depth. Absent in phloem and just present in the medullary rays and zylem. Cells darkening and filling up irregularly to a depth of not more than 1 c.m., the maximum depth being at the pith.

9th day.—Starch immediately below cut in all tissues for 1 m.m., absent below this in all tissues up to almost 1 inch. Blocking distinct in the medullary rays and pith in order mentioned.

12th day.—Starch immediately below cut. None in any tissue up to 1 inch depth below that. Blocking very distinct, specially in the medullary rays.

24th day.—Starch immediately below cut surface to a depth of 1 m.m. Absent from all tissue below that to $1\frac{1}{4}$ inches except a trace in pith here and there up to $\frac{3}{4}$ inch. Blocking distinct in medullary rays, and wood vessels, and cells are fairly dark. Cell contents very resistent to boiling with alcoholic potash and subsequent treatment with hot oil of cloves.

31st day.—The same, but no starch at all up to about 1 inch.

To anyone reading Swarbrick's paper, these observations will be found closely in accordance with what he describes, and without suggesting that my investigations have been in any way complete, I offer these experiences as affording a certain amount of evidence that the tea bush does not differ in the physiology of its response to wounds from trees of temperate climates. I might venture the opinion that the evidence, though incomplete, is fairly strong.

Coming to the more practical question of the influence of manuring on this process of healing, my contention for many years has been that the time of application of the manure with reference to pruning has a very great influence on its effect.

Without going deeply into the history of Ceylon tea manuring, I should like to point out that until comparatively recent times all manuring, with the exception of a dressing of slag and potash or lime at the time of pruning, was done while the tea was being plucked. Tea makes a wonderful recovery from pruning

as regards its leaf growth, and it is not altogether to be wondered at that in the early days of its cultivation it was not considered necessary to manure it until plucking began. The act of pruning was, indeed, looked upon in the old day as a kind of manuring, for it brought the tea on with apparently renewed vigour. The tea bush is cultivated for its leaf and the production of leaf was all that was sought for by manure applications.

That this type of manuring did not do all that was required is, I think, very evident to anyone who has had the opportunity of seeing pruned tea in all parts of the Island during the last 15 or 20 years, and I do not think that anyone seeing the average pruned field to-day would consider it a proof that its treatment has been correct. Decay of the wood is everywhere to be seen, and an important point to remember is that this decay began and has continued to get worse during those years when manuring was done in the manner described. If this manuring system had provided the tea bush with its real needs, it would surely not have reached the stage of poor wood, to say nothing of decay, in which we now find it. If, on the other hand, a change in the system of manuring can bring about a change in the diseased conditions of the bushes, it is perhaps not too much to conclude that it was the system of manuring that was at fault and not that manure have no effect in preventing decay.

While I am anxious to make no statement which may appear to claim what has not been proved, I can definitely state that I have seen extensive development in the healing of pruning cuts and even of old cankered wound in Ceylon tea since the proper manure was applied at the time the tea was pruned, and that these estates where this healing is now to be noticed did not produce this type of growth under the old system of manuring only during the flushing period.

Some of you may be prepared to state that tea which to your knowledge has not been manured at pruning time is showing healing, and I would not dispute that statement. I know certain cases of it myself, and I am familiar with tea which has never been manured at all and yet which shows quite good healing going on to-day. These instances do not, however, seem to me to affect my main argument, in fact they rather confirm it. My contention is that if tea is sufficiently vigorous, and especially if it shows vigorous growth during its recovery from pruning, it will heal its pruning cuts in the way I have described. Whether this vigour is conferred on it by the natural fertility of the soil or by manure does not matter, and the fact remains that by far the larger proportion of the tea in Ceylon is unable to carry on the natural healing process without the help of manure, and that it has not done so until this manure was applied at the time of pruning.

The application of pruning mixtures is now becoming comparatively common and so is healing, and anyone who has only had the opportunity of examining tea in the field on an extensive scale during the last year or two might easily assume that the healing which is now found has always been going on, but I can assure you that this is not the case. I saw so little of it at one time that I nearly came to the conclusion that tea did differ from the trees of temperate climates, and even from the trees one finds in the jungle and on roadsides in Ceylon, in being unable to produe callus tissue, and it was not until I made trials with the type of manure which I have since found so useful that callus formation began on anything like an extensive scale. When Ceylon tea was young it doubtless healed most, if not all, its pruning cuts and where one finds specimens of the old high centred bushes which have not since been cut down, one generally finds that the original centring cut has healed completely and that there is evidence of healing of old pruning cuts also; but that took place many years ago and before starch depletion and carbohydrate starvation became acute. To-day it does not take place, in the vast majority of cases at least, unless special measures are taken to encourage it.

I have here some specimens from an estate which has been manured at pruning time for about 10 years, although very moderately so at first. Its wood was formerly in the same state of decay as the majority of Ceylon tea, and it had continued in that condition for a good many years although manured liberally under the old well known system. If the altered treatment at pruning time has had no effect on callus formation why should this tea now exhibit the excellent growth of callus and woody tissue which these specimens show ? I can assure you that the actual amount of plantfood applied under the present system was less, when healing first began, than was applied on the old system, the only change being that part was applied at pruning time. The total is now practically the same as in the old days.

I do not say that we should strive to grow great rolls of callus tissue such as the first of these specimens exhibits. In fact I should describe this growth as tending to freakishness, but I exhibit this specimen as an illustration of what can be done in the way of inducing callus growth by manuring in a particular way. You will see that besides the big lump of callus tissue, all the pruning cuts of two years ago show callus growth, and many of them have completely healed. I can assure you that no such effect as this was seen on the estate in the old days.

It may perhaps not be considered of great importance that the bush should be able to cover the surface of a clean pruning cut with callus tissue. No great harm apparently comes to the tea if it does not, but apart from the fact that it seems to me

important to close all these possible points of entry for decay or for the attacks of insects, it is I think obvious that if branches and stems which have been rotting away for years can be healed up, something very tangible has been gained. I have here two specimens of such healing from the same estate, and I think you will agree that the present condition of this wood is better than the old and that it is in a fair way to get rid of the decay altogether.

The difficulty of healing irregular and decayed cavities such as these last two specimens exhibit is obviously greater than the case of a clean pruning cut, but I think it probable that the process is essentially the same. If it is, and if the wood below the cavity is sealed by wound gum then it is probable that the process of decay is arrested by this barrier and the growth of callus is enabled to take place beneath the dead tissue and above the sealed layer. If these ideas are correct, the fact that decay has gone deeply into the wood may make the healing process slower and more difficult, but should not make it impossible, for there must be living tissue at some depth below the decay and it is here the blocking of the wood should take place whether the cavity is big or small.

It seems that when callus tissue begins to grow along the edges of a wound such as this specimen shows it becomes sometimes infected presumably by a fungus, which causes its death and decay, and this re-infection may continue with successive layers of callus which subsequently form. This condition has occurred, although in my experience not very often, but when it does it looks as though the natural process of healing were insufficient to get rid of the trouble, and the removal of the source of infection seems necessary. Whether this should be done by the removal of the diseased tissue or by the application of a fungicide, or by both, I do not know, but if a fungicide is produced that will kill the fungus responsible for the infection and subsequent decay I would certainly be inclined to use it in such cases. I would use it, however, in conjunction with suitable manuring, for fungicides do not of themselves induce callus growth. My experience with the dressings commonly advocated, of which tar is the most common, has been that they do not prevent decay. I believe others have different experiences, but that is mine.

I have seen a great many heavily pruned fields in which the cuts have been tarred, often after very expensive cleaning out of decayed tissue, and with the best will in the world I have not been able to convince myself that anything has been gained by the tarring. Decay appears to go on beneath the tarred surfaces in quite as many cases as beneath the untarred, and it certainly does not seem to me that tar gives the protection required. A point often brought up in favour of tar and similar preparations,

is that it is waterproof, and that decay is brought about by the infected surface being wet. Decay may be hastened by wet, but I do not think callus formation is retarded by it. I have found good healing on cut surfaces covered with moss, and which were thereby kept pretty constantly damp, while investigations at Long Ashton in 1922 indicate that coverings which keep the tissue moist promote the formation of callus. I do not object to tar because it may delay callus formation.

A little delay is unimportant if freedom from infection can be assured, but I should like to see it more convincingly demonstrated than the field trials I have seen have done, that tar has the necessary fungicidal properties. The trouble with these external dressings seems to be that the more effective they are as fungicides the more destructive they are on the plant tissues, and it has been suggested that any wound dressing which adversely affects the exposed zylem, phloem and cambial tissues—the last in particular—loses thereby any value it may have because it lowers the powers of the plant to heal its wounds. This may be wholly or partly true, but it does not exclude the possibility that a substance may yet be found which will fulfil the required conditions.

Meantime I confess I am much more hopeful of improving the condition of the wood on our tea bushes, both as regards resistance to and recovery from disease and decay, by a rational system of manuring than by the application of such fungicides as we have at present at our disposal.

Discussion.

Mr. Stockdale.—Before the discussion takes place, I would like to say that many of us know the improvements that have taken place on a number of estates in Ceylon by the adoption of a system of manuring which has been outlined by Mr. Keiller. I have received a letter from Mr. J. A. M. Bond in which he says that he regrets that he is unable to be here to-day, but he gives some details of one estate over which he has charge. They are as follows :—

"In particular Mr. Keiller's advice has been followed and his methods practised for the past five years on an estate in Matale.

"Five years ago the tea on that estate was riddled by shot-hole borer and was yielding just over 300 lb. of made tea per acre. The bushes were contracted and a mass of old pruning wounds and diseased tissue.

"Yields have steadily risen to 625 lb. per acre all over and are still rising and what is even more important the bushes have grown practically new frames while the formation of 'callus' or healing has been rapid and most marked.

"These results have been achieved by the application of a pruning mixture applied at pruning time, followed 12 months later (in a two-year pruning cycle) by the application of a 'General' manure mixture. Prunings have been consistently buried and all available forms of 'green manures' have been regularly mulched in with the fork at the time manure has been applied.

"In view of the discussions which sometimes arise as to the effect of manuring on the quality of made tea it is interesting to record the fact that the teas have well maintained their relative position in the market and that the prices obtained for these teas compare very favourably with neighbouring Estates.

"Adequate treatment at pruning time by means of quiet acting soluble nitrogenous fertilisers combined with heavy 'green manuring' forms the basis of this programme of tea cultivation and I have found that programme uniformly successful under varying conditions of soil and climate all over the island."

There is one other point I would like to make brief reference and that is the importance of this question in regard to the termite problem. As you all know termites are one of the most serious problems the tea industry is faced with at the present time and is the subject of special investigation. Mr. Jepson has the investigations in hand and he has been recently to America studying the question there. The conclusions which have been arrived at so far, though not final, are that termites find their entry into tea bushes through die-backs, and if any system can be adopted by which one can secure good callus formation, the termite is in a fair way of being defeated in its operations, and Mr. Jepson is making investigations along that line as well as on other lines indicated by his visit to America. I do not wish to discuss the matter further as I am perfectly certain that there are a number in this Hall who would like to address Mr. Keiller on certain points in this interesting paper which we have had placed before us this afternoon.

His Excellency the Governor said that he was sure before they proceeded to the discussion they would wish him to express in their name to Mr. Keiller their very sincere thanks for the valuable and interesting paper he had read to them. He hoped that anybody who had questions to ask and observations to make, would ask their questions and make their observations forthwith.

Mr. Petch.—I understand that Mr. Keiller's views on the healing of wounds are based on a series of experiments carried out for several years. It would be of interest if Mr. Keiller would give an account of his experiments in detail, stating whether they are comparative, *i.e.*, done at the same time, what manures were used, and how the results were estimated.

It is often possible, in a field without special manuring, to find a few bushes which show a very much better callus development than others. What is wanted, in judging the results of an experiment, is some estimate of the relative results over the whole of the experimental blocks. It is, of course, difficult to do that with mathematical accuracy. But the bushes might be classified, as regards healing, into, say, three groups—good, fair, and poor. If a whole field has been treated, a number of consecutive bushes, say 25, in a row should be examined. Then another 25 should be taken in another row at a predetermined distance from the first. And this should be repeated until 100 or 200 bushes have been judged. In that way, an idea of the general effect would be obtained, and it would be possible to estimate whether the effect could be attributed to the treatment, or was merely accidental. To pick out, here and there, bushes which show good healing, cannot prove anything.

An interesting point which requires investigation is the difference between the results claimed at this elevation, and the results obtained at higher elevations. Mr. Keiller admits (p.10.) that the results are more rapid at low and medium elevations than at high. But I have examined an up-country estate where the result was nil. In this connection, it must be remembered that callus growth is most rapid when it first begins: afterwards it slows down. If there is no particular callus growth within six months of manuring, one must count that manuring a failure from that standpoint.

In 1905 or 1906 I had some excellent examples of healing of longitudinal cankers on tea branches about an inch in diameter. Dr. Mann, who saw those specimens, declared that they were the best thing he had seen during his visit to Ceylon. That result was attributed to manuring with an excess of potash. As far as I remember the specimens were from an up-country estate.

I think, however, that there is a possibility that those results were not due to potash, and similarly that the present results may not be due to nitrogen, but that there may be some factor common to both which has been overlooked. That is where a physiologist is required.

Mr. Keiller has stated (p. 3) that the belief that potash is the cause of wood growth is traceable to the statement so frequently found in text-books that carbohydrate formation ceases in the absence of potash, from which it was an obvious conclusion, as wood is largely made up of carbohydrate. But scientific work is not done in that way, without testing "obvious conclusions." There are experiments, more than twenty years old, which show that potash manuring does increase the proportion of wood. Parallel to that, there is the practical man's objection to excessive potash manuring, namely, that it increases the amount of woody fibre in the leaf.

Mr. Keiller refers to the statement so frequently found in "text-books", as though it were incorrect. It is fully established. He will find it in Russell's *Soil Conditions and Plant Growth,* which is usually considered reliable.

Mr. Keiller suggests that the advocates of potash are influenced by the propaganda of the German Potash Syndicate (p.8). I was rather under the impression that my reaction to propaganda is negative, and I think the Chilean Nitrate Committee agree with me in that view. But Mr. Keiller has overlooked the fact that his suggestion lays him open to a very obvious retort.

I would ask Mr. Keiller whether he still holds the opinion that potash is not necessary in tea manuring. I ask the question because I have seen several of Mr. Keiller's prescriptions, and they all contain potash. If Mr. Keiller has changed his opinion, does not that mean that he has discarded all the results of his experiments?

With regard to the application of preservatives to wounds on tea, I have pointed out elsewhere that Mr. Keiller has misapplied the results of the experiments he quotes. I cannot imagine how anyone acquainted with wood-rot on Ceylon tea can argue that no protectives or preservatives are necessary. Recently I was called in to examine a field of tea up-country which had been treated by tarring three years previously, because the Directors, influenced by published statements, thought the expenditure unnecessary. The exposed wood, three years after tarring, was quite hard and decay had evidently been arrested. On the same estate I was shown another field, two years from pruning, where the wounds had been treated with Bordeaux mixture, which is nearly equivalent to doing nothing. I had

been told that this second field was better than the tarred field, but there was no difficulty in demonstrating that the exposed wood in that field was soft and decaying.

The use of Bordeaux mixture for this purpose appears to be a waste of time. Bordeaux mixture cannot soak into wood. It is a suspension of a powder in water, and if the water soaks into the wood the powder is filtered out. Of course, during wet weather some soluble copper compounds will be regenerated from the Bordeaux mixture sediment, but the probable fate of those is that they are washed away by the rain.

Mr. Petch also raised other points of criticism. He referred to the question of wound-gum and quoted from a paper by Brookes in the Silver-leaf disease investigations. It was there urged that in fruit trees that in spite of wound-gum occurrence it was considered necessary to recommend the application of preservatives. The Tea Research Institute had not been able to discover any signs of wound-gum in tea. All tests for wound-gum had been negative and what Mr. Keiller described was certainly not wound gum. The Institute still recommended the application of washed tar to pruning cuts. He stated that Mr. Keiller's experiments were uncontrolled and related to bushes picked out here and there. Callus formation might be stimulated by manuring but it often died back.

Mr. Keiller said that Mr. Petch had contended that the fact that the coloured dye had not penetrated the piece of wood did not prove the existence of the wood-gum barrier. At any rate, it proved the existence of some barrier, and he could not think of any other explanation than that some obstruction had formed to prevent its penetrating the piece of wood. He did not say that wound-gum existed in the tropics in exactly the same way it existed at Home. He had merely put forward evidence to show that the process appeared to be the same here as it was at Home, and he had found this by microscopic examination. He had assumed, perhaps quite wrongly, that the process that had taken place in the series of observations made by him, was the same as the process described by Swarbrick at Home. He laid claim to no more than that. Mr. Petch stated that he had entirely failed to find any barrier. He, on the other hand, had found exactly what Swarbrick had described in his paper, namely the formation of a viscous substance right across the cut surface. He had also found starch exactly where the investigator at Home had found it.

As regards fungicides, he personally still doubted their necessity. In the case of badly cankered wounds which were liable to infection, he would use a fungicide if he were convinced it would stop the trouble, but his own experience in Ceylon had been that tar did not stop the trouble. That, however, did not exclude the possibility that something might be found which would fulfil the conditions required. Mr. Petch had said that he (the speaker) had never told anybody what manures he recommended to be used. He had told a great many people and had written the whole story in reports whose number was legion. He had not gone into that question that day because it was not called for. The basis of his arguments was that he would apply such manures calculated to take effect quickly; that is to say, that they would be absorbed largely in the period between pruning and tipping, and for that purpose, he used readily available nitrogenous manures. As regards potash, Mr. Petch had said that he had stated that it was of no use, but yet always used it. It had caused a great deal of amusement. . . . .

Mr. Petch.—I do not think it should amuse you. You say here, "I very soon discarded potash....."

Mr. Keiller.—I am not denying what I said. I am merely trying to explain perhaps. For instance, he (the speaker) had said that morning that

he did a great number of soil analyses, which he did not believe in, but merely because he had been asked to do it. In the case of potash, he believed that the average Ceylon soil contained sufficient potash to render the continuous use of potash unnecessary, and that is the point he very often had to emphasise. He did not think it necessary to do it that day. He had never said that potash was unnecessary for tea for any stage of pruning or any part of the tea bush, but that the continued application of fertilizer was, in his opinion, unnecessary. He confessed to putting in a little potash because it found its place in the original mixture. He was not in favour of putting it into every mixture as an absolute necessity. When he (the speaker) was in Java, he was given a book in which a large number of soil analyses were included. No figures were given for potash. The author stated that they had satisfied themselves so thoroughly that the average soils in Java and Sumatra had sufficient potash that they did not even determine the potash in the soil analyses. If any man insisted on having potash ascertained, they did it and charged an extra 50 guilders. He did not want to be mistaken. He had never declared that potash was not necessary for tea—it was one of the essentials but it was not necessary to apply it every year, for potash fertilizer did not conduce to the growth of the wood. Mr. Petch had accused him of picking out a bush here and a bush there to show callus formation, and that he knew cases where this occurred quite well without manure. The whole trend of his remarks would make it quite clear that he based his conclusions as to the efficacy of manure at pruning time on full results over a good many years on numbers of estates situated in many parts of the Island. Mr. Petch had asked whether his experiments were comparative. They were not comparative in the strictly scientific sense, and he admitted that they were open to all sorts of scientific objections on that account. All he claimed was that this formation of callus became common on estates all over the Island as soon as this type of manuring was started and that it had not been common before. He did not agree with the statement that if nothing happened within six months of manuring, nothing would ever happen. In this instance his critics had overlooked the cumulative effect of manures. He did not object to a little retardation of callus formation by the application of tar, if it ensured against infection, but his own experience with fungicides, was that they did not appear to do any good.

Mr. Westrop confirmed what Mr. Keiller had stated in regard to the effect of easily available manurial applications before pruning. He had himself observed on several occasions the excellent callus formation.

His Excellency the Governor.—I am sure we are all thankful to those who have taken part in this very interesting discussion. There has been an interesting difference of opinion between two of our experts. This difference of opinion may or may not be soluble, but at any rate, it has added zest to our discussion, and we thank both protagonists for their contribution.

His Excellency then called upon Mr. A. W. R. Joachim to read his paper entitled "The results of drainage and leaching trials at Peradeniya during 1927."

The Results of Drainage and Leaching Trials at Peradeniya During 1927.

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IN a previous communication by the writer (1) an account was given of preliminary experiments made during 1926 to study the absorptive powers of Ceylon soils for fertilizers and the losses of the latter by leaching from these soils. It was there indicated that the losses of fertilizers from 6-inch layers of soil due to a total rainfall of 3 inches during 24 hours were, except for the nitrates, hardly appreciable. In continuation of this investigation, a pot experiment was started in December 1926 to determine the amounts and composition of drainage waters from pots filled with soils to a depth of 3 feet, and to each of which fertilizers at the rate of 60 lb. of the fertilizing constituents were added. There were altogether 18 pots, 9 of which were cropped and 9 uncropped. Two pots, one cropped and the other uncropped, were controls. The following fertilizers were added, each to a cropped and an uncropped pot:—Blood Meal, Nitrate of Soda, Nitrate of Potash, Sulphate of Ammonia, Cyanamide, Superphosphate, Muriate of Potash and Sulphate of Potash. The pots were made of galvanised iron. They were cylindrical in form, 1½ feet in internal diameter and 3½ feet high with the base sloping from the circumference towards the outlet pipe at the centre. The drainage waters were collected in galvanised iron cylindrical vessels placed directly under the outlet pipes.

The pots were filled as follows:—A piece of tile was placed over the outlet at the base, and the whole of the latter covered with a layer of gravel. Unsieved soil was then compacted into the pots to a depth of 9 in. from the top, and finally soil, sieved through a quarter-inch sieve, to a depth of 3 in. from the top. The soil was a good loam well supplied with organic matter (7·8%). It is regretted that the pots were filled with soil and subsoil taken to a depth of 1-1½ feet and mixed together, and not with soil and sub-soil in their natural relative proportions and positions. This has to some extent rendered the results less useful than they might have been, and more divergent from what would have been obtained had drain-gauges or lysimeters of blocks of undisturbed soil *in situ* been used in the experiments. As it is, the two factors responsible for some of the abnormal results obtained from these experiments are (1) the soil disturbance, (2) the mixing of soil and sub-soil in filling the pots. It would take

at least from 4 to 6 years before the soils in the pots could settle down to anything like normal conditions of compactness. An experiment carried out to ascertain the degree of compactness and pore space in the pots showed that only $\frac{3}{4}$ths of the soil from a hole 1 c.ft. in content could be compacted to the same degree as in the pots, into a wooden box of the same cubic content. The pore space of the soil in the pots is therefore one-third more than that of the soil *in situ*. The crop selected was the ordinary *Hibiscus* as it is a quick-growing perennial. The crop was grown from cuttings, 4 rooted cuttings being planted in each pot at the end of December, 1926. The pots were filled early in November. The manures were spread on the surface of the soil in the pots at the rate of 60 lb. per acre of Nitrogen or Phosphoric Acid or Potash, and forked to a depth of 3 inches, on the 13th January, 1927. Samplings of drainage waters from the pots were made from time to time, depending on the amounts of liquid percolated, the amount of percolate from each pot measured and an analysis made of each of the percolates at every sampling. The methods of analysis were the standard methods adopted for such determinations.

The Amounts of Drainage.

In Table I below are shown the amounts of drainage waters obtained.

Table I.

Treatment	Rainfall	Drainage	
		Uncropped	Cropped
	Inches	Inches	Inches
Blood Meal ...	76·6	49·43	28·43
Nitrate of Soda ...	76·6	48·27	26·58
Nitrate of Potash ...	76·6	51·11	31·80
Sulphate of Ammonia ...	76·6	48·78	30·97
Cyanamide ...	76·6	49·48	30·77
Superphosphate ...	76·6	51·94	34·66
Muriate of Potash ...	76·6	52·15	28·85
Sulphate of Potash ...	76·6	50·48	30·24
Control ...	76·6	47·95	29·2
Average ...	76·6	49·96	32·5
		%	%
Average Drainage ...		65·1	38·6
,, Evaporation and Transpiration		34·9	61·4

It will be observed that while the average percentage of drainage from the uncropped pots is 65·1 or about two-thirds the rainfall, that from the cropped pots is much less—38·6 or about two-fifths the rainfall. An examination of the detailed data shows that when the rainfall is heavy and continuous the drainage

is about the same from the cropped and the uncropped pots. This is partly due to the low transpiration from the crops when the humidity of the atmosphere is high owing to continuous rain. The average percentage of evaporation from the uncropped pots is 34·9 and of evaporation and transpiration from the cropped pots 65·1. Assuming equal evaporation from both sets of pots owing to soil conditions alone, the percentage of moisture lost by transpiration is 26·5 or about one-fourth the rainfall. It may be of interest to mention here that at Rothamsted the average drainage during a period of 55 years from lysimeters of undisturbed soil is 50·2% for a rainfall of 29·27 inches (2). If these experiments had been carried out on undisturbed blocks of the same soil, the drainage percentage would most probably have been less than what has been obtained. The high drainage percentage can be attributed to (1) the disturbance of the soil, (2) the compactness of the soil in the pots being only three-fourths that of soil *in situ* and the greater pore space, (3) the nature of the soil, (4) the high rainfall, its intensity and uneven distribution, (5) a probable temperature and humidity effect.

An examination of the data shows that there are striking variations in the amounts of drainage obtained from the different pots. These variations are only to be expected owing to (1) the soils in the different pots not being compacted to the same degree in each pot (2) in the case of the cropped pots, the unequal growths of the crop and hence the different amounts of water transpired, (3) the possible effects of the manures. These differences are of great importance, as it will be seen later that the amounts of soluble fertilizing constituents lost are directly dependent on the drainage. Of the cropped pots, it will be noted that the muriate of potash and superhosphate pots have the highest and the control and the nitrate of soda pots the least amounts of drainage. In the case of the cropped pots superphosphate has again the highest drainage and nitrate of soda the least. The low drainage from the nitrate of soda cropped pot might partly be due to the very good growth of the crop in this pot.

The Relation of Drainage to Rainfall and Temperature.

Glancing over Table II. and Fig. 1 it will be observed that in the case of both the cropped and uncropped pots, there is a significant positive correlation between the rainfall and the average drainage during a period. In the former case the correlation co-efficient was + ·9344 and in the latter + ·7106. These results therefore conform with what has already been found by other workers at Rothamsted, Pusa and Cawnpore, that for any particular place the drainage of water from soils is positively correlated to the rainfall.

Table II.

Last Date of Sampling		Rainfall	Drainage	
			Uncropped	Cropped
		Inches	Inches	Inches
29-1	...	6·09	3·76	4·24
1-3	...	2·68	1·50	1·24
16-3	...	4·27	1·83	0·93
23-4	...	4·91	2·53	0·54
16-5	...	7·51	6·84	6·10
2-6	...	6·70	3·72	1·53
24-6	...	4·13	3·42	1·03
19-7	...	5·80	3·02	0·46
9-9	...	4·53	2·75	0·67
30-9	...	7·54	4·84	2·65
31-10	...	10·42	8·33	6·07
4-1-28	...	12·02	7·92	3·88

An examination of the detailed data shows that when the rainfall is heavy and continuous the drainage percentage is high and is greater than when the rain though heavy, falls intermittently. It also shows as previously mentioned, that in the former case, the differences between the amounts drained from the cropped and uncropped pots are much less marked.

With regard to drainage and soil temperature, the data show that there is no direct relationship between the two. The average soil temperature during a period appears however to be affectted both by the total rainfall and the distribution of rain during the period or immediately prior to it. The data show that low soil temperatures are obtained when the total rainfall and/or the number of days on which rain fell are great, and *vice versa*.

The Composition of the Drainage Waters.

Analyses of the drainage waters obtained under the conditions of this experiment show that calcium oxide (lime) and nitrates are found in largest quantities, chlorine in lesser amounts, and potash to a much smaller extent. No appreciable quantities of phosphate or ammonia are found in the leachings. In the case of those constituents leached out in largest quantities, much smaller amounts were found in the drainage waters from the cropped than the uncropped pots. Towards the latter half of the year when the crop had grown well the amounts of fertilizing constituents found in the drainage waters from the former were very small. The amounts of fertilizing constituents in the drainage waters were found to be greater, the greater the drainage and hence the rainfall. This was especially so with the nitrates and lime. Table III. and Figures 2 and 3 will illustrate the above conclusions clearly.

Table III.

Composition of Drainage Waters.

p.p.m. = Average parts per million.

(U) Uncropped
(C) Cropped

Total Solids.

		lbs. per acre.	p.p.m.	Ratio (U/C
Control	(U)	3906·6	322·8	2·1
,,	(C)	1854·0	280·1	

Nitrate Nitrogen. / Ammoniacal Nitrogen.

		Nitrate Nitrogen: lbs. per acre.	Nitrate Nitrogen: p.p.m.	Nitrate Nitrogen: Ratio (U/C)	Ammoniacal Nitrogen: lbs. per acre.	Ammoniacal Nitrogen: p.p.m.	Ammoniacal Nitrogen: Ratio (U/C)
Blood Meal	(U)	505·0	45·1	3·2	·83	·07	·6
Blood Meal	(C)	159·8	24·8		1·39	·22	
Nitrate of Soda	(U)	481·9	44·1	3·8			
Nitrate of Soda	(C)	124·1	20·6				
Nitrate of Potash	(U)	509·8	44·0	3·3			
Nitrate of Potash	(C)	153·1	21·3				
Sulphate of Ammonia	(U)	509·0	46·1	3·5	·64	·06	·6
Sulphate of Ammonia	(C)	145·6	20·8		1·12	·16	
Cyanamide	(U)	547·3	48·8	3·4	·54	·05	·2
Cyanamide	(C)	180·7	25·9		2·85	·49	
Control	(U)	510·5	47·0	2·9	·58	·05	·5
Control	(C)	175·9	26·6		1·15	·17	

Phosphoric Acid.

		lb. per acre.	p.p.m.	Ratio (U/C)
Superphosphate	(U)	·096	·008	·93
Superphosphate	(C)	·10	·014	·93
Control	(U)	·11	·013	·92
Control	(C)	·12	·018	

Lime.

Sulphate of Ammonia	(U)	553·1	50·0	2·7
Sulphate of Ammonia	(C)	203·9	29·1	
Muriate of Potash	(U)	628·6	53·2	3·2
Muriate of Potash	(C)	195·0	29·8	
Control	(U)	589·4	54·3	2·1
Control	(C)	274·9	41·6	

Potash.

Nitrate of Potash	(U)	60·4	5·2	1·5
Nitrate of Potash	(C)	39·4	5·5	
Muriate of Potash	(U)	69·9	5·9	2·3
Muriate of Potash	(C)	30·6	4·7	
Sulphate of Potash	(U)	75·9	6·6	2·4
Sulphate of Potash	(C)	32·0	4·7	
Control	(U)	65·7	6·1	1·4
Control	(C)	46·4	7·0	

Chlorine.

Muriate of Potash	(U)	161·5	13·1	2·4
Muriate of Potash	(C)	68·2	9·8	
Control	(U)	115·2	10·2	1·8
Control	(C)	65·6	9·8	

An examination of the analytical figures obtained for each constituent would appear to point to the following, apart from the general conclusions already referred to.

Total Solids.—The average amount found in the drainage water from the uncropped pot was 2·1 times that from the cropped pots.

Nitrates.—(1) Next to lime these are found in the drainage waters in greatest amounts which are abnormally high.

(2) The amounts of nitrate found in the percolates at each sampling are almost directly proportional to the amounts of drainage, and the rainfall during the period prior to sampling, being greater the greater the drainage and rainfall and *vice versa*.

(3) The losses of nitrate nitrogen from the soil, as a result of the addition of 60 lb. of nitrogen per acre in various forms, if they do occur at all, will be small when compared with the losses from the soil itself which are over 500 lb. per acre. The loss of nitrate from the control pot is as great as or greater than that from the other pots.

(4) It is obviously not possible to determine the different amounts of the added nitrogen lost from the individual pots through leaching, but the analyses show that the amounts and concentrations of nitrate in the drainage waters from both cropped and uncropped pots are greatest from the cyanamide and least from the nitrate of soda pots. It should not however be inferred that similar results would be obtained under all other conditions, nor can it be deduced from the data so far obtained from this experiment that the nitrogen from cyanamide is more easily lost in the drainage water from soils than that from nitrate of soda. But the comparatively smaller quantity of nitrate found in the drainage water from the nitrate of soda cropped pot may be attributed, partly at least, to the low drainage from this pot as a result of the good growth of the crop in it. It is not understood why the concentration of nitrate nitrogen in the drainage water from the cyanamide pots is the highest of all the pots.

(5) The average amount of nitrate found in the drainage waters from the uncropped pots is about 3½ times that from the cropped pots.

The extremely high figures for nitrates in the drainage waters are due to (1) the disturbance of the soil from its natural position and hence the greater bacterial activity owing to the increased aeration and the mechanical disturbance of the bacteria into new quarters where there are fresh supplies of food, (2) the soil and sub-soil not being placed in their natural relative positions in the pot, (3) the high drainage as a result of the high rainfall (76·6 inches) compared with that of temperate countries and

the lower degree of compactness of the soil in the pots as compared with soil *in situ*, (4) high soil temperatures and hence great bacterial activity. The soil temperature ranged from 24°-30°C which is about the optimum temperature range for the nitrifying bacteria (5) the soil being well supplied with organic matter. Though abnormal, these figures for nitrates are not surprising when it is realised that at Pusa (3) as much as 261·5 lb. nitrate nitrogen per acre were lost from the 6 ft. drain gauge of undisturbed soil when the rainfall was 75·7 inches and drainage 28·49 inches as against a drainage of 50 inches in the experiments at Peradeniya. The effect of the transference of soil from *in situ* to the pots in increasing bacterial activity and nitrification of the nitrate already present in the soil, can be gauged from an experiment of the French soil worker Dehérain. (5) He found in the drainage water from pots filled with transported cultivated soil as much as 466 to 664 parts per million of nitrate as against an average of about 45·8 at Peradeniya. He also found that no less than 196·6 lb. per acre of nitrate nitrogen were lost from a hoed fallow plot when the drainage was only 11·5 inches against the average of 50 inches in these experiments. The figures obtained from these experiments should in no way be considered as representing the actual losses of nitrates under normal field conditions as (1) the conditions of the experiment are not normal (2) they are only one year's results. It is essential that the experiment be carried out for at least 4 or 5 years more, before more nearly normal results can be obtained. The actual losses from field conditions would be much less than what these experiments show, though the latter indicate that the losses of nitrate from tropical soils would be greater, probably much greater than those from temperate regions for reasons already stated. It may be useful to refer here to the figures obtained for nitrate losses through drainage waters from drain gauges of undisturbed soil at other places. At Cawnpore in India (5) with an average rainfall of 32·7 inches the amounts of nitrate nitrogen found in the drainage varied from 80-100 lb. per acre per annum for the 6 ft. gauges during 1903-1919 and from 50-60 lb. for the 3 ft. gauges. During later years (1919-1926) the quantity lost was considerably less being 25-30 lb. per annum. Pusa (3) figures for 1906-1910 were 75 and 66 lb. per acre respectively when the average rainfall was 42·4 inches and those of Rothamsted (2) 40 lb. in the earlier years, then 30 and finally 25 lb. in the later years, the average rainfall being 29·3 inches. Reliable data on the losses of nitrate from Ceylon soils can only be obtained if proper lysimeters or drain gauges of soils *in situ* are erected.

Some results of practical value are clearly demonstrated by these experiments. They show that large amounts of nitrate nitrogen would be made available to crops by judicious and care-

ful soil cultivation provided there is sufficient nitrogen and organic matter in the soil, and that the excessive cultivation of soil is uneconomic owing to the depletion of the lime, nitrogen and organic matter reserves of the soil.

Lime.—(1) Lime is found in the drainage waters in greatest amounts and is evidently in the form of nitrate of lime.

(2) The amounts of lime found in the leachings are dependent on the drainage and the rainfall, in the case of both cropped and uncropped pots.

(3) The effect of fertilizers on the amounts of lime found in the drainage waters is not apparent owing to the soil disturbance and the different degrees of compactness in the pots. The loss from the control is less than that from the muriate of potash pot owing to the high drainage from the latter, and greater than that from the sulphate of ammonia pot.

(4) The average amount lost from the uncropped pots is 2·7 times that from the cropped pots.

The high losses of lime are due to (1) the high drainage, (2) the increased production of carbon dioxide and hence greater solubility of the calcium carbonate in the soil owing to the increased aeration and high soil temperatures.

Potash.—(1) The amounts of potash present in the drainage waters are much smaller than those of nitrate and lime and are dependent on drainage and rainfall to a lesser extent than the latter.

(2) The concentration of potash in the drainage waters is much the same as of those from cultivated fields at Rothamsted.

(3) The average amount found in the drainage water from the uncropped pots is about twice that from the cropped pots.

Chlorine.—(1) The amounts of chlorine present in the drainage waters are dependent on drainage and rainfall.

(2) The loss of chlorine from the muriate of potash pot is greater than that from the control. This is probably due to the greater drainage from the former as well as to the chlorine lost from the fertilizer itself.

(3) The average amount lost from the uncropped pots is about twice that from the cropped pots.

Ammonia.—(1) Only very small amounts of nitrogen as ammonia are found in the drainage waters.

(2) The drainage waters from the cropped pots contain greater amounts of ammonia than those from the uncropped pots.

Phosphoric Acid.—Only minute traces of phosphoric acid are found in the drainage waters from both the cropped and the uncropped pots.

The above results indicate that the effects of soil disturbance on the amounts and concentrations of drainage waters are considerable, and such as to render the latter much higher than what would have been obtained from drain gauges of undisturbed soil *in situ* as those at Rothamsted, Pusa and Cawnpore. It is likely that if the soil had been left to settle in the pots for 3 or 4 years at least before the experiment was started, more nearly normal results would have been obtained.

References.

1. A Preliminary Investigation on the Absorption of Fertilizers by Ceylon Soils—A. W. R. Joachim, Department of Agriculture, Bulletin, No. 75.
2. Soil Conditions and Plant Growth—E. J. Russell, pp. 245 and 354.
3. Records of Drainage in India—J. W. Leather, Memoirs, Department of Agriculture, India, Chem. Series, Vol. II., Part I.
4. The Soil—A. D. Hall, pp. 223 and 265.
5. Drainage Waters at Cawnpore—H. N. Batham, Mem. Dept. Agri., India. Chem. Series, Vol. VIII., No. VIII.

Discussion.

Mr. Keiller said that he would like to confirm from his own little experience, the findings of Mr. Joachim. He thought that there was a good deal of exaggeration in people's minds as to the rate of loss of nitrates under Ceylon conditions. That was one point which Mr. Joachim did bring up. They knew that there was no chemical action which fixed nitrates in the soil and there was no physical mechanism, except a little absorption and the surface tension effect which prevented nitrates being washed off, and having a little knowledge of those two they would think that it is washed off. As Mr. Joachim had pointed out, where they had a good crop, the loss of nitrate was much less than if they had a bad crop.

There was on the other hand, the retentive effect of the growing crop itself, as Mr. Joachim's findings had proved. He had experienced further that the growth in rubber from nitrate applications annually was better than the growth from any other fertilizer he had used by way of comparison, or that of the unmanured control plot.

Mr. T. Eden.—I have listened to what Mr. Joachim has said with very great interest and there are a number of points arising from the data presented in this paper, which, if they are confirmed by subsequent work, should lead to results of practical importance. I would confine my attention entirely to the question of loss of nitrogen. In the first place, Mr. Joachim said that the nitrate losses are as great in the control as in the manured plots. He ascribes this to the high organic matter content of the soil. The importance of this finding can, to my mind, be more adequately judged if the emphasis is altered and we say that the data show that the losses from manured plots are no greater than from the control.

The second point is that in respect of nitrate loss. Nitrate of soda, sulphate of ammonia and blood meal acted alike in these plots. (The small differences which appear to occur are not large enough to have any significance until confirmed by statistical examination.) This means that even on the uncropped soil, the readily available and soluble nitrate has not been lost to an extent greater than its less available neighbour, sulphate of ammonia, or the alleged slow-acting blood meal.

Photo by L. S. Bertus

Showing Pots Used in Leaching Experiment. The Pots in front are Uncropped. Crop at a Late Stage of Growth.

Yet if nitrification and leaching were the only factors concerned, a differential effect might have been expected. The solution to this problem is offered by regarding the nitrogen changes in the soil as being part of a complete cycle which includes both the breaking down and the building up of complex substances. The nitrogen lost in drainage is the balance between what is produced by degradation of higher forms on the one hand, and what is re-assimilated by the micro-organic population or used by higher plants on the other hand.

The two processes of breaking down and building up by way of micro-organic protoplasm go on side by side.

The figures under review suggest that such a process has been taking place, so that the loss of added nitrate and ammonia has been checked by their being brought into the "synthetic" portion of that nitrogen cycle. The agency which makes this conservation possible is the organic matter.

Investigation at Rothamsted and in America show that within limits the ratio of carbon to nitrogen in the soil is 10. That leads to my third point which is that without an adequate supply of organic matter the conservation of even added nitrogen (that is, as apart from what the organic matter itself supplies) is impossible.

Given a soil rich in humus, then within the range of fluctuation possible to the carbon nitrogen ratio added nitrogen can be preserved by the process of biological assimilation and gradual release. Given, on the other hand, a soil poor in humus, added nitrogen will be lost in drainage, because in the absence of the energy supplied by the organic matter, assimilation cannot take place. These data then suggest that in the practical field a number of points should be tried out. Where green manuring is carried on intensively and organic matter is consequently well supplied, these results suggest that losses would not be greater using the more soluble sulphate of ammonia at Rs. 9/- a unit than with the so-called less available blood meal at Rs. 24/- a unit of nitrogen.

If this is the case, if this conservation of nitrogen can be demonstrated in the field, it provides an added reason why green stuff should find favour on estates in Ceylon. In this connection it is interesting that not only the classical experiments but modern ones also at Rothamsted point to a higher level of efficiency from a judicious use of artificial and organic matter than from either by itself. In parenthesis it may be mentioned that the contribution of organic matter to a soil by organic manures like blood meal is negligible, being on a 500-lb. application about 1—50 per cent.

These points, I believe, are important enough to warrant not only a continuance of these leaching trials, but full investigation on the field side. These latter would have to be accurate and comprehensive, and it is hoped that work at present in hand at Nuwara Eliya will provide a sound basis for such experiments when the time is ripe for their accomplishment.

His Excellency the Governor.—I thank Mr. Joachim on your behalf for the very instructive paper which he has just read and I believe that these results are the labour of careful calculations. I have had the opportunity of seeing the useful work carried on by Mr. Joachim here, and I hope that those of you who are interested in this will put it to practical experience.

His Excellency then called upon Mr. T. H. Holland to read his paper entitled "Experiences in the use of creeping cover crops in tea cultivation with special reference to *Indigofera endecaphylla*."

Experience in the Use of Creeping Crops in Tea Cultivation, with Special Reference to *Indigofera Endecaphylla.*

T. H. HOLLAND, Dip. Agric. (Wye),

Manager, Experiment Station, Peradeniya.

THE following would appear to be the advantages to be gained by planting a creeping cover crop in tea:—

(1) Soil erosion is checked and top soil retained.
(2) The soil is shaded and loss of humus thus prevented.
(3) The penetration of the roots of the cover crop help to open up the soil.
(4) When the cover crop is thoroughly established weeding expenses are considerably reduced.
(5) There is a gradual increase of humus from the decomposition of the leaves which fall from the cover crop.
(6) If a leguminous crop is used all the above advantages may be obtained without the cover crop depleting the soil of nitrogen at the expense of the tea, and a nett gain in nitrogen may even result.

Objections which might be put forward are:—

(1) Obstruction to the progress of coolies.
(2) Harbouring of leeches and snakes.
(3) Difficulty in applying manures.
(4) Undue absorption of plant-food materials at the expense of the tea with consequent depression of yields.
(5) In drier districts, excessive transpiration of moisture with possible detriment to the tea.
(6) An undue absorption of labour and funds to deal with the cover crop.
(7) The smothering of the tea by the cover crop.

The Choice of a cover crop.—Though other crops may have been tried, the writer is only aware of three ground covers having been specially planted in tea in Ceylon, viz; *Desmodium triflorum*, *Dolichos Hosei* (Vigna), and *Indigofera endecaphylla.*

The effects of *Desmodium triflorum* on young tea are reported to have been most unfavourable, probably owing to the close mat formed by this plant if left untouched.

Dolichos Hosei has been planted in tea on a few estates; its proclivity for climbing is probably its principal drawback for this purpose but it is believed that the expense of keeping the creeper off the bushes would not prove a very serious item.

Indigofera endecaphylla is the plant which appears at present to fill the rôle most satisfactorily and the remainder of my remarks will be confined to this plant.

Experience with Indigofera endecaphylla.—Ten acres of old tea on the Experiment Station, Peradeniya, were planted with *Indigofera endecaphylla* in the north-east monsoon of 1925. Since then considerable areas have also been planted on estates.

The plots on the Experiment Station planted with Indigofera were previously under a manurial experiment and after planting the cover crop the same manures have been applied, the same style of pruning, tipping, and plucking employed, and all conditions kept as nearly as possible identical with those previously existing.

The period between the 1923 pruning and the 1925 pruning has been taken as the basis of comparison with similar periods after the planting of the cover crop. Soil analyses were made in all plots before the planting of the cover crop and again before the first pruning after planting. The general results of two years' experience were published in the *Tropical Agriculturist* for February, 1928.

In the light of experience gained on the Experiment Station and elsewhere it will now be advisable to examine to what extent the objects of planting a cover crop in tea enumerated at the beginning of this paper have been achieved by planting Indigofera, and to what extent the possible disadvantages apply.

Prevention of Soil Erosion and retention of surface soil.—At Peradeniya the cover established has been so uniform and satisfactory that, to the outward eye, it appears impossible that any further erosion could take place.

Mr. A. W. R. Joachim, Agricultural Chemist, in his report on the soil samples taken from these plots says: "The Analysis shows that the soils are all light, sandy and gravelly loams and that compared to the samples taken two years ago they have on the whole slightly greater proportions of fine gravel and coarse sand, the quantities present now varying between 50% and 63%. The proportion of finer soil particles in the 1927 samples is correspondingly less and now varies between 16% and nearly 25%. It would therefore appear that in spite of the Indigofera there is a washing away of a small proportion of the finer soil particles due to erosion." It must be borne in mind however that the period in question includes the early stages of growth of the creeper and that it was fully 6 months before a general cover

was formed. No one can doubt that a cover such as now exists at Peradeniya forms one solution of the soil erosion problem.

Shading of Soil and Saving of Humus.—It is a well known fact that in tropical countries, exposure of the soil to the sun results in a loss of humus, and therefore eventually of fertility. It is true that on many estates the cover of tea is so good that there is practically no exposure of the soil. On such estates there is possibly little need for a ground cover crop; but this enviable state of affairs is by no means universal and where there is exposure *Indigofera endecaphylla* offers an effective shade.

The Root Action of the Cover Crop.—All the Indigoferas are deep rooted, and *Indigofera endecaphylla* puts down a strong tap-root which cannot fail to materially assist in opening up the soil.

The Smothering of Weeds.—When once a thick cover is established Indigofera has been found to effectually keep down most weed growth with the exception of couchgrass, and a reduction of at least fifty per cent. in weeding costs could reasonably be expected.

Increase of Humus.—One of the most striking points in the plots at Peradeniya planted with Indigofera is the thick layer of dark decomposing organic matter that can be found at any point under the creeper. This is reflected in the soil analysis which shows a satisfactory increase of organic matter compared with the analysis taken before Indigofera was planted.

A comparison with soil conditions in adjoining clean weeded plots shows the obvious superiority in physical texture of the soil under Indigofera.

Saving of Nitrogen by the Use of a Leguminous Plant.—The reason for selecting a leguminous plant as a cover crop is that most plants belonging to the natural order of leguminosae have the power of assimilating atmospheric nitrogen, and are thus able to supply their own needs without depleting, to any great extent, the supply of nitrates in the soil. This does not necessarily mean that there will be a nett gain of nitrogen though in some cases this may occur. After two years at Peradeniya the position as regards nitrogen content as discovered by analysis is summed up by the Agricultural Chemist as follows:—

" It will be noticed that in five cases there is a distinct increase of over 0·01% of nitrogen, in four cases a distinct fall, and in four cases hardly any difference. On the whole there is a small decrease in the nitrogen content in the 1927 samples over those taken in 1925. These results seem to indicate that while the Indigofera did probably increase the supply of soil nitrogen, the amount contributed by it and that applied by manures was in some cases less than that taken up by the tea during the period. In other plots the nitrogen added to the soil by the leguminous

crop and the manures was in excess of the requirements of the tea. It is certain that sampling accounts to a certain extent for the difference, it being a matter of extreme difficulty to get a true representative sample from any large extent of soil. It is however likely that determinations made at the end of a further two years will give more conclusive results than have so far been obtained."

We will now turn to the objections which might be put forward and endevaour to ascertain how far these can be said to apply to the planting of Indigofera in tea.

Obstruction to the progress of coolies.—Indigofera does not offer any obstruction to progress through a tea field. In fact walking over Indigofera is as easy and pleasanter than walking over bare soil.

Harbouring of leeches and snakes.—Leeches have never been found in Indigofera on the Experiment Station and this is confirmed by an estate which has a considerable area of tea planted with this cover crop. Snakes have occasionally been found at Peradeniya but no serious trouble has been experienced in this respect.

Difficulty in Applying Manures.—There is no practical difficulty in applying manures though the expense of the operation is certainly increased. At Peradeniya the method employed has been to make a vertical cut with a grass knife down the centre of the row to be manured and then drag back the creeper to the side of the row with mamoty forks. By this method sufficient roots are left in the row for the cover to be established again in a remarkably short time. Clearing alternate rows for manuring may cost about Rs. 5·00 per acre.

Absorption of plant food materials at the expense of the tea.—This is an important point. It is of course true that any cover crop will take up food materials, either present in the soil or applied in the form of manures, which might have been absorbed by the tea. This is not necessarily pure loss, however. To begin with the cover crop may take up soluble food materials which would otherwise have been lost through leaching, either because the root area of the tea did not cover the whole ground or because such materials were present in such quantities greater than could be absorbed at one time by the tea. Secondly, if the presence of the cover crop is desirable, its improved growth may be reasonably expected to prove of ultimate benefit for the tea. The practical point at issue however is whether the presence of Indigofera does in fact depress the yields. At Peradeniya compared with the two-year inter-pruning period preceding the planting of Indigofera, the average yields of the plots concerned have remained practically stationary, although the rainfall for the second period showed a deficiency of 12·31 inches com-

pared with that of the first period. It can be reasonably concluded, therefore, that so far Indigofera has neither depressed nor increased the yields of tea to any marked extent. The obvious improvement in the physical texture of the soil, however, the increasing layer of organic matter covering the surface, the diminution of soil erosion, and the healthy appearance of the tea, all give good grounds for hope that yields will almost certainly eventually increase.

Loss of Moisture in Dry Districts.—It is commonly thought that the shading of the soil by the growth of a crop will necessarily result in a saving of soil moisture. WIDTSOE in "*Dry Farming*" states:—"Soil water may be lost by evaporation from the plants themselves. While it is not generally understood, this source of loss is, in districts where dry farming is properly carried on, very much larger than that resulting from either seepage or from direct evaporation. While plants are growing, evaporation from plants, ordinarily called transpiration, continues. Experiments performed in various arid districts have shown that one and a half to three times more water evaporates from the plant than directly from well tilled soil."

Tea is not cultivated in arid regions such as are referred to, but the point may be of importance in the drier tea districts on the Uva side. At Peradeniya moisture determinations have been made on three recent occasions to compare conditions in bare soil scraped monthly and soil under Indigofera. In February, 1926, after 31 days' drought more moisture was found in the first six inches of the soil under a cover crop than in the bare soil, but in the deeper layers more moisture was found in the bare soil.

In September, 1927, samples were taken again from the same plots under still drier conditions. On this occasion the Indigofera soil held more moisture than the bare soil at all depths except the 12-24 inches layer; and even in the latter layer the difference was hardly appreciable.

In February, 1928, further samples were taken in other plots and it was found in this instance that the total moisture up to 24 inches was greater in the plots under cover crops, though the bare soil contained more moisture in the 12-24 inch layer. It would appear probable therefore that over most of the tea districts no undue loss of moisture need be anticipated from growing a cover crop.

Labour and Funds.—The amount of labour required to deal with Indigofera will depend on the cultural operations it is decided to undertake. Presuming that manuring is done and that one annual application is made to alternate rows of tea, the only absolutely essential operation is cutting and dragging back the Indigofera to allow manures to be applied. Against this can be set the saving of labour on cleaning drains and weeding. In the

former case only roadside drains will need any attention, and the labour required for weeding can be reduced by at least 50%.

Smothering of Tea Bushes.—Indigofera does not climb in the manner that Vigna, Centrosema, and other creepers do. It will grow up through the middle of a tea bush but not cling on to it. Such growth is very easily removed. On one estate this work is entrusted to the plucking kanganies. In the case of young supplies of course more care must be taken to keep the plant free of the creeper, but in general no trouble need be anticipated from this source.

Conclusions.

1. There are good arguments in favour of planting a cover crop in tea.
2. *Indigofera endecaphylla* forms a suitable crop for this purpose.
3. At Peradeniya Indigofera appears up to date neither to have depressed nor increased yields of tea to any marked extent.
4. Analyses of soil before and after planting Indigofera show a satisfactory increase of organic matter but the total nitrogen present in the soil has remained more or less stationary.
5. Further experience is needed before it can be definitely stated that the planting of Indigofera in tea is a paying proposition, but there are good grounds for expecting that it will prove to be so.

Discussion.

His Excellency the Governor.—We are thankful to Mr. Holland for his very instructive paper. He has raised a question of a very grave interest in its application to the larger question of soil erosion. I hope that some of the practical planters will give us the benefit of the experience and views on the subject.

Mr. C. Huntley Wilkinson.—I have planted *Indigofera endecaphylla* as a cover plant throughout the tea in about two acres on a very steep face. When it grows thick, it is cut back and dug in when the field receives its usual dose of manure. No particular care is taken not to root it out and it requires very little attention other than to keep it from growing above the tea. It is, on the other hand, not particularly difficut to eradicate. I would, however, hesitate to plant it indiscriminately throughout a tea estate at present, but certainly think it will prove invaluable on steep faces.

Where *Oxalis Corrimbosa* has been established for many years on the steep 25-acre field on Talankande Estate, the last two and a half years seem to confirm the opinion I have written about before. This field yielded as much as 892 lb. per acre in 1927 as against an estate average of 775 lb. In 1926 (the year in which it was pruned) it yielded 340 lb. per acre against the last corresponding pruning year of 299 lb. This may be partly due to the fact that in 1926 and 1927 this field received an enhanced dose of 100 lb. of manure per acre to what the rest of the estate received. I do not, how-

ever, think that the figures given can in any way be made to show that it was necessary to give preference in this way to this field.

MR. HOLLAND stated that during the South-West Monsoon of 1927 a fair number of vacancies were supplied and it was particularly noticeable that those planted under the existing cover of Indigofera came on better than those in the bare plots.

MR. GORDON PYPER.—I would like to ask Mr. Holland how he found tea after pruning coming up on these Indigofera fields. I went to the Experiment Station and it was a disappointment to me to see that the young tea had a sort of choked look about it.

MR. HOLLAND.—I may say that I have noticed no difference in the tea under Indigofera and the tea not under Indigofera. I could not see that there was any superiority one over the other.

MR. WILMOT PERERA asked whether the Agricultural Department had any experience of "gotukola" as a cover crop. He added that he wrote to the Department and was informed that it might be allowed to grow but he had found that its growth had checked the growth of the permanent crop.

MR. R. DE V. GODFREY enquired how deep the cuttings of Indigofera were planted.

MR. HOLLAND.—My experience is that, provided the conditions are favourable, Indigofera will grow whatever you do to it.

Continuing he stated that the method employed on the Experiment Station was to make a hole with a digging fork and plant three cuttings together. The cuttings are simply laid in with their ends protruding.

MR. GODFREY.—I asked the question because I planted some in poor soil and most of it died.

MR. R. G. COOMBE remarked that the growth in the first year with him was almost negligible, but the plants came on all of a sudden and are now growing splendidly.

MR. WANIGASEKERE.—I wonder whether soil inoculation is necessary.

MR. STOCKDALE replied that Ceylon soils were sufficiently well equipped with bacteria to render this treatment unnecessary.

MR. COOMBE stated that at elevations higher than at Peradeniya it was highly advisable to prepare the soil before planting indigofera. "But," he said, "at elevations such as Mr. Holland mentions, if you put it upside down or downside up it does not very much matter."

MR. HORSFALL stated that the solution on poor soils was to first prepare the soil and then plant 9-inch cuttings, burying two-thirds of each underground.

MR. O'CONNOR asked whether it was difficult to eradicate Indigofera after some years.

MR. HOLLAND referred him to the article in the *Tropical Agriculturist*.

MR. HUNTLEY WILKINSON observed that he had not found the abnormal tap-root development mentioned by Mr. Holland.

MR. STOCKDALE.—The work that Mr. Holland had described is still in the experimental stage and I would just like to mention that any person here interested in this question of Indigofera could see the plots in the Experimental Station during the visit of the members of the Conference to the station to-morrow, and the practical points could be discussed on the spot. I think that is the most satisfactory way of dealing with the matter.

At this stage HIS EXCELLENCY THE GOVERNOR said that Mr. Gordon Pyper was willing to postpone the discussion which he had to lead on behalf of the Kandy District Planters' Association.

(The first day's session was then brought to a close).

Tuesday, May 8, Morning Session.

His Excellency the Governor.—Ladies and Gentlemen, before we open the proceedings of this morning, it is your wish I am sure, that I should express briefly on your behalf the expression of the sorrow with which we learnt of the death of a distinguished fellow-countryman, Mr. J. J. Wall. He was well known and much loved as the Chairman of the Chamber of Commerce, and in that capacity and many others he had many points of contact with the Agricultural community. He was also specially distinguished for the thought and care he gave to the betterment of the conditions of the not highly paid commercial employees of this country. I will ask you to be so good as to do so by rising in your seats in token of our sorrow at Mr. Wall's death and of sympathy with his widow and children.

(The vote was passed all present standing.)

His Excellency then called upon Mr. C. E. A. Dias to read his paper entitled "Soil erosion with special reference to rubber."

Soil Erosion.

With Special Reference to Rubber.

C. E. A. DIAS.

EROSION is the removal of soil material by air or water in motion. I shall deal only with erosion caused by water.

Cause of Erosion.—Erosion occurs whenever rain falls on unprotected sloping land—such as our clean-weeded estates—so rapidly or in such quantities that the soil cannot absorb the water as fast as it falls. Only that water which is not absorbed by the soil—the " run-off "—causes erosion. The " run-off " depends on:—

1. The slope or topography of the land.
2. The texture and structure of the soil.
3. The vegetative covering.
4. The character of the rainfall.

1. **The slope or Topography of the land.**—The run-off from hilly land is the greatest and causes the most erosion.

2. **The Texture and Structure of the soil.**—Coarse soils absorb a much larger proportion of the rainfall than the fine grained ones. The rate of absorption depends on the size of the pores, and not on the total pore space in the soil. This fact explains the rapid absorption of rainfall by the coarse-grained soils, and the slower action of the fine-grained ones. However, if the latter are loose and open from recent tillage, their absorption compares favourably with that of the coarser soils.

3. **The Vegetative Covering.**—The surface of a natural forest is usually covered with leaves and twigs which protect it from erosion. Estates that have recently been planted with cover crops, especially creeping plants, and are well established, are also protected from further erosion. Such surfaces suffer little so long as this protection remains undisturbed.

4. **The Character of the Rainfall.**—A gentle rain will be absorbed entirely by almost all soils since it does not fall more rapidly than the water can percolate through the soil, thus preventing complete saturation of the surface. The rainfall we get in Ceylon, especially in the low-country, cannot be termed gentle rain by any means. The heavy torrential rain in Ceylon soon saturates the surface, and then absorption by the soil cannot take place any faster than percolation from the surface into the lower strata.

The Results of Erosion.—The removal of organic matter and nitrogen. The surface soil contains the greatest part of the organic matter and so is the richest and most productive part of the soil. The removal of any appreciable amount of this stratum reduces the amount of plant food, especially the nitrogen, rendering the soil less productive than formerly. It also exposes the yellowish or reddish sub-soil which is heavier and more difficult to work than the original surface soil. They are less productive than the original land, and even the regular application of artificial manure will not bring them back to their former condition. The soil that is carried off by the run-off finds its way to the canals and rivers, thus filling their beds and causing floods.

In the United States, 10,600,000 acres of farm land have been abandoned and 3,800,000 acres have been devastated by soil erosion.

In Ceylon we have no statistics of this sort. However, any one travelling during the rainy months in the planting districts would see our rivers running red, carrying volumes of rich surface soil.

Some time ago I had occasion to make certain measurements on a well cultivated rubber estate, and found that in a small area of about 1800 square feet of surface, no less than 91 cubic feet of top soil had been carried off by the run-off within the last 20 years, thus exposing the lateral roots of the trees very badly. I should call this surface top soil the Capital of the land. Ceylon being an entirely agricultural country, and depending solely on its agricultural products for its maintenance and prosperity, this surface top soil is the Capital of the Island. It is up to one and all of us to do everything we can not only to protect this vitally important Capital of the Island, but also to preserve it for the benefit of the generations unborn.

Methods of Prevention and Reclamation.—I propose to deal with this subject under the headings "New Clearings" and "Old Plantations."

Prevention—New Clearings.—Soon after a jungle is felled, burned and cleared, the first thing to be done is to sow all kinds of green manure seed, both erect and creeping. This should be followed by pegging out the land to plant on the contour of the ground, let it be for tea, rubber or coconut. Holes should be cut and refilled with top soil, and after that contour platforms should be cut at such distances and sizes, dipping into the hill so as to hold all the rainwater that falls on the ground and prevent the run-off described above. I need not describe here the exact work of contour platforms as a lecture was delivered on this subject some time ago, and this method of planting is now fairly known and adopted in most parts. I can now safely say that contour platforms have been a success. If these are cut to a proper mathematical working all the rain that falls on the ground is arrested and the "run-off" is prevented. This water sinks into the ground and since there is no "run-off," there is no erosion. Moreover, rubber planted on contour platforms grows extremely well and is far ahead of rubber of the same age planted under the old system. Another method of preventing erosion is to establish a vegetative covering. The best covering for this purpose is nitrogenous green manure creeping cover plants such as *Vigna oligosperma*, now known as *Dolichos Hosei*, *Calopogonium* and *Centrosema* for rubber and coconut, and *Indigofera endecaphylla* for tea.

I have found that Vigna will not grow readily in a new clearing. Vigna grows better under a shade. Therefore I would start planting *Tephrosia candida* and *Tephrosia Vogelli* after the contour platforms are cut and when these are full grown, start planting Vigna under the shade of Tephrosia. When planting Vigna, if cuttings are not available on the spot, it is best to plant it 12 ft. by 12 ft. and about 4 or 5 slips 3 ft. long burying them in the middle. If the weather is bad shading can easily be done with a few branches of Tephrosia. This should take root and extend 4 or 5 feet in about three months. Further cuttings can be taken from these patches and interplanted this time 6 ft. by 6 ft., and by this means within a year to 18 months of first planting, a new clearing can be easily fully covered with Vigna.

Calopogonium and *Centrosema* grow very well in new clearings, but these have the disadvantage of creeping up the plants.

I do not like *Desmodium*. When a new clearing is burnt, and if selective weeding is resorted to, *Desmodium* comes up very fast. In some places, within a year, a beautiful cover is established. But very soon this gets very woody and tends to

retard the growth of rubber. I am getting all my new clearings cleared of this green manure. If contour platforms are cut, I would keep the platform area clean weeded for a couple of years. If the planting is done under the old method, then I would advise that a space of at least 6 ft. in circumference be kept clean weeded all round the rubber plants.

Reclamation—Old Plantations.—I have experimented with old rubber and old coconut with success. In the case of rubber, stone terraces were built on the lower side of the rubber tree or trees on the contour of the ground to be on a level with the root collar of the tree whenever there were exposed roots. These exposed roots were covered with soil taken from pits cut about 30 feet apart in the drains to a size of 30 cubic feet. These pits no only supplied earth to cover these exposed roots but act as reservoirs, and conserve the rain-water and prevent the "run-off." After this, creeping leguminous plants were established. Under old rubber, I have tried several varieties of green manure both erect and creeping. It had good success only with *Tephrosia candida* of the erect plants and Vigna of the creeping plants. The greatest difficulty is experienced in establishing the first few plants of your cover crops. In certain places, however much you may plant, it may take root but it will not extend. In such places you have to help it on with a little manure. Then you have to watch whether they are attacked by snails. You cannot find them during the day. They hide under leaves or stones and only come out at night. So it is necessary to send out some intelligent coolies with torches at night and collect them night after night. During dry weather they are not active, but in rainy weather they are very active and can easily be caught at night. As a rule, snails are found near buildings, and very few are found away from buildings.

In reclaiming old washed out soil I would always plant *Tephrosia candida* with manure as a first step and bury the loppings once in six months for a year or two. This will help to replace some of the washed out organic matter and nitrogen. When Tephrosia is fully established, Vigna can be planted and it will readily take root and establish itself. The surface is thus kept covered with soil-binding creeping leguminous crops. On old coconut plantations, individual contour platforms were cut dipping and sloping into the higher side of the ground with a drain 2 ft. by 2 ft. by 6 ft. on the furthest and lowest side of the platform. I find this work most valuable especially in districts where the rainfall is less than 80 inches a year, and they help to arrest all the "run-off" rain water and thereby the severe effects of a drought are minimised.

I had no opportunity of tackling tea estates, so I shall leave them alone.

On eroded, exhausted soil, it may not be possible to grow nitrogenous cover plants without any help. Most Ceylon soils are deficient in the element Phosphorus to such an extent that it becomes the limiting factor. It is especially important in the growth of legumes. Its addition helps to make possible the building up of soil by the larger growth of nitrogenous soil-renovating crops. In addition to this it improves and increases the crop whatever it may be.

In certain parts some planters object to cover plants for fear of snakes and leeches. On most of my estates I have a good cover of Vigna established for the last 3 years. On three of these no venomous snakes have been seen so far. In one estate, a cobra was killed after watching for it for three months. This was a cobra that had lived in a rock cave close by. However, if a small fee is given for each head, there should be no trouble from snakes. With regard to leeches, if you prevent cattle from trespassing on your estates, you can keep off leeches.

I feel that I have now occupied your precious time far too long, and before concluding, I must acknowledge my indebtedness to Lippincotts College Texts on Agriculture for some very valuable information on this subject.

Discussion.

His Excellency.—Ladies and gentlemen, we are all very much indebted to Mr. Dias for the very interesting paper which he had just read. He has indeed placed the whole planting community under a deep debt of obligation for the experimental work he has done on his estates and the tests he had carried out for the prevention of soil erosion and with regard to the usefulness of cover crops in rubber plantations.

Continuing His Excellency remarked that the subject of soil erosion was one of the most important which had come before the Conference. It was important not only to the planter himself by reason of the soil being washed away but also to the rest of the community owing to the silting of rivers by soil which instead of doing good to the estates to which it belonged did harm to the unfortunate people living down the waterways. The subject was raised the previous evening in the paper read by Mr. Holland in relation to cover crops and the time was too late then to allow the discussino to continue. He (the speaker) would like the discussion to include any questions in regard to tea which were not disposed of the previous evening. They would, no doubt, discuss the subject of soil erosion primarily in relation to rubber and incidentally to tea and coconut.

Mr. Stockdale enquired from Mr. Dias which Desmodium he was referring to. The small leafed *Desmodium triflorum* or the larger leaved species.

Mr. Dias replied that the small leaf was more harmful than the big. He further stated that the small leaf "desmodium" had a tendency of binding the ground.

Mr. Wanigasekere enquired whether forking would overcome that binding tendency.

Mr. Dias replied that if they forked they removed its beneficial covering effects entirely. What is the good of having something that has to be planted, removed and replanted.

Mr. A. N. Philbrick asked whether there was anybody present who could give him his experience of cover crops in new tea clearings. On the estate he had to deal with, there was heavy clay sub-soil. His personal experience was that he could not with any degree of satisfaction establish young tea if they planted their cover crops at the same time. It was his experience that if they planted cover crops a year or two later, it was like shutting the stable door after the horse had bolted as the soil then would have been washed off. He wished to know whether Indigofera would do well.

Mr. Solomons stated that he found the planting of Indigofera in steep places come up very satisfactorily. Further, the establishment of cover crops depended a good deal on the nature of the soil and the conditions under which it was cleared. Generally speaking one should not experience difficulty in establishing some sort of cover crop. *Desmodium* in some districts came up almost at once but it practically suffocated the plants. As regards forking the difficulty was to carry it out at the right time.

Mr. A. T. Sydney Smith.—As has been already pointed out by Mr. Solomons, *Desmodium triflorum* practically suffocates the plant, and I have seen clearings very seriously kept back not in one case but in many cases. You may say 'fork it.' The difficulty is to carry out the forking at the right time.

Continuing Mr. Smith stated that it was his experience that Indigofera grew freely in old tea. There were, however, places where tea itself was good cover and was a natural protection to the soil and it was a very moot point whether that did not meet all the circumstances of the case. On estates where tea had itself provided such a protection soil erosion had been reduced greatly. It was only where those conditions did not exist that soil erosion occurred.

Mr. Stockdale stated that with regard to the question raised by Mr. Philbrick that morning in regard to the use of cover crops in young tea, there was a prevailing opinion as far as he could gather among the planting community that the planting of such cover crops did in many cases retard the growth of young tea. He (the speaker) had seen the clearings of Mr. Horsfall and there had been no set-back in that case. On the other hand, he had seen one case in the Ratnapura District where the naturally grown Desmodium which Mr. Dias referred to were left and for the first year or two, the tea thrived very well but subsequently there was a retardation and the cover crops had to be taken off. Therefore, he thought, they would be wise at the moment to consider in young tea contour terraces and contour hedges of such plants as Boga medeloa.

He personally was greatly in favour of planting definite contour hedges of tea above the drains and of putting the plants in not more than 1 foot apart. These contour hedges of tea should help to solve the solution of soil erosion in tea.

With regard to older tea, there was no difficulty in growing cover crops. Experience on the Experiment Station had shown no retardation of growth, and no reduction of crops.

In conclusion, Mr. Stockdale stated that the paper that Mr. Dias had read to them that morning indicated clearly what he had been doing in his estates. He had also given the results of his experiments to the public and he thought that the Agricultural Community were greatly indebted to Mr. Dias for that information and for his public-spirited action in making it available.

Mr. R. G. Coombe emphasised the evil of scraping instead of weeding as a matter that the planting community should take up whole-heartedly. By a little more weeding instead of scraping, he said, a great deal could be done to conserve the soil. The use of the hand and some other instrument which will not scrape would go a long way towards reducing soil erosion. The scraper should be entirely forbidden.

Mr. A. R. Westrop gave an account of his observations in Malaya and Sumatra. He stated that Mr. Dias had mentioned the difficulty of establishing Vigna. In Sumatra, he found in the American plantations, the whole of their steep land covered with very fine growth of Vigna whether on the shade or in the open, and they appeared to experience no difficulty. He emphasised the point mentioned by Mr. Dias about planting green manure immediately land was felled.

At this stage His Excellency asked Mr. J. Mitchell to open the discussion on "Cover crops and green manuring in rubber cultivation."

Cover Crops and Green Manuring in Rubber Cultivation.

J. MITCHELL, A.R.C.Sc.,

Organising Secretary, Rubber Research Scheme (Ceylon).

Introduction.

THE subject of cover crops and green manuring in rubber cultivation has so often been under discussion that it might appear almost superfluous to bring the matter forward again. Nevertheless, there is still some misconception as to the benefits or otherwise to be derived from the growing of cover crops under rubber and a good deal of puzzlement as to the best means of utilising such covers when they have been established.

There is an extensive literature dealing with the various species of plants used as cover crops, and green manures, their habit of growth, and the best means of establishing them successfully and it is not, therefore, considered necessary in this place to go into details in this connection. On the other hand it appears to the writer to be most important that there should be a better understanding of the purpose underlying the practice of growing these plants and that it is necessary for us to know how to obtain the maximum benefits from them.

For convenience, it is proposed to deal with the subject under two separate headings—(1) Cover Crops and (2) Green Manuring, though the two dovetail or overlap at many points. Thus, all cover crops may be utilised as green manures but there

are several herbaceous and shrubby plants of the erect type of growth which make excellent green manures but are not strictly cover plants.

1. Cover Plants.

(a) **For the Prevention of Soil Erosion.**—There can be little doubt that the primary purpose of growing cover plants in rubber cultivation is to prevent soil erosion. As soon as the land is cleared from jungle it becomes exposed to the baking action of the tropical sun and to the scouring action of the tropical rains. Under the system of clean weeding which has been practised on practically every rubber estate in Ceylon this condition has been maintained throughout and everywhere one now sees the effects of this policy. The rubber trees were allowed undisputed tenancy of the soil with the result that they now have the undisputed tenancy of the sub-soil while all the soil has been removed to the paddy fields and rivers below. In other words, if rubber is grown under conditions of clean weeding the top soil is, in a few years from the time the jungle is felled, practically certain to be lost. Before considering the means for preventing this loss it might be well to ask why one should be anxious to preserve this top soil. Everyone realises in a vague sort of way that the top soil is valuable but it does not appear to be fully appreciated how vitally its retention affects the continued fertility of the soil and the general well being of the rubber grown thereon.

The top soil handed to us after the jungle growth is cleared consists of finely divided particles of mineral matter and of the accumulated remains of dead animals and plants (humus) and is inhabited by a vast population of micro-organisms (soil bacteria). These bacteria are constantly at work breaking down complex nitrogenous compounds in the soil leading to the formation of soluble nitrates which are immediately available as plant food for the rubber. The continued activity of these micro-organisms, however, depends on there being a sufficiency of humus and of water in the soil and everything possible should be done to ensure that these conditions are present. That is, this layer of soil is not merely a dead stratum overlying the sub-soil but is an active medium providing the source of all present and future fertility.

If left exposed the direct action of rain water quickly removes this layer of soil and there is a steady depletion of the raw and manufactured materials necessary for the sustenance of the rubber. In addition, the removal of top soil involves the removal of the micro-organisms which play such an important part in creating fertility.

Certain mechanical means such as platform terraces, stone terraces, and silt-pits have been employed each of which are valuable for the prevention of soil erosion but none of these fulfil

all the conditions necessary to ensure the continued fertility of a soil. It should be our purpose not only to prevent the removal of the soil but to maintain the humus content and to stimulate the activities of the various micro-organisms therein. This can only be done by the establishment of a suitable cover plant. Those which have shown the best results in Ceylon are *Vigna* (*Dolichos Hosei*), *Centrosema pubescens* and *Centrosema Plumieri*. These are creeping plants which, in course of time, form a close carpet over the ground and completely protect it from the direct action of the sun and of the rain and thereby reduce soil erosion to a minimum.

(b) **For Improving the Physical condition of Soils.**—We have seen that a cover plant serves the purpose of retaining top soil by screening it from the direct action of the sun and rain but that is not the only function it performs. The penetration of the roots of cover plants serves to break up hard soils and clays often to a good depth. This renders them more friable, improves aeration and facilitates the rapid movement of soil water. (Photographs passed round illustrating the root growth of various cover plants.)

The more broken up and friable the soil is the less is the direct runaway of water during rains. A common condition on Ceylon properties is that known as "capping" in which we have an overlying stratum almost impervious to water. To break up this layer is one of the most difficult problems for Superintendents and one which gives much anxiety when proposals for cultivation and manuring are being considered. Such a condition would not have been produced had cover crops been grown from the commencement of planting and if a cover can be successfully established the penetrative action of the roots brings about a marked improvement in this respect.

(c) **For the Conservation of Soil Water.**—When the soil is exposed to the tropical sun it gradually becomes baked and hardened. Rain water falling on this surface penetrates with difficulty and the greater part of it runs over the surface and is lost. Again, the evaporation from such soils is much more rapid than from friable soils owing to uninterrupted capillarity in the soil and there is considerable loss of water from this cause. As an adequate supply of soil water is necessary for the activities of the micro-organisms in the soil and for the growth of the rubber it is desirable to maintain this to the fullest extent. If a good soil texture is created and there is a sufficiency of humus in the soil an adequate supply of soil water will be ensured and this can best be brought about by the establishment of cover crops.

On the other hand it is sometimes urged that cover crops compete with the rubber for water owing to transpiration from their leaves. Experiments in Tea at Peradeniya Experiment

Station have shown that for the first two years of growing a cover crop rather more water is lost by transpiration from the leaves of the cover than from bare soil but the difference is not significant except during long droughts. Afterwards the accumulation of humus and the penetrative action of the roots of the covers leads to an opposite state of affairs and less moisture is lost than is the case from bare soil.

(d) **For the Preservation of Nitrogen.**—One of the principal elements required by rubber for satisfactory growth is nitrogen and everyone is familiar with the rapid improvements which take place in backward areas of rubber after a course of nitrate manuring. Newly opened land is usually well supplied with nitrogen but this steadily declines under cultivation depending on the amount of erosive action which takes place. As soon as the land is exposed after clearing the jungle the soil nitrogen is rapidly changed to nitrate and for the time being conditions are very favourable to the growth of the young rubber which has been planted. There is not this rapid change from soil nitrogen to nitrate in land under cover crops and it is probably this fact which has influenced the clean weeders to declare that the growth of the young rubber is better in clean weeded areas than in areas under a cover plant. This sudden access of fertility, however, cannot be maintained under the severe conditions of tropical sun and rains, exhaustion sets in, and growth slows down. The need for more nitrogen then becomes imperative and artificial manures are advised.

If, however, a suitable leguminous cover crop is established from the time of opening the supply of nitrogen can be maintained and though the growth of the rubber may appear to be slower it will prove, in the long run, to be better sustained. Leguminous covers have the power, through the nodules on their roots, to utilise atmospheric nitrogen and to fix it in the plant so that when this dies or is dug into the soil the whole of this nitrogen is returned to the soil. The constant decay of the root system of a cover crop and the accumulation of the fallen leaves increases the humus content of the soil and under this cover the micro-organisms can carry out their work at the maximum rate. This leads to a definite improvement in soil fertility instead of a state of exhaustion such as takes place in clean weeded areas.

2. Green Manuring.

It has been shown that cover crops serve to reduce erosion, to improve the texture, to increase the water content, and to conserve the nitrogen of soils. These services alone would be of great value in rubber cultivation but there is no reason to rest contented with these benefits, great as they are, for by the proper utilisation of cover crops they can be made to serve other useful purposes.

If we allow cover plants to grow for too long a period without paying any attention to them a state of staleness may set in causing the cover to lose vigour and sometimes to die off altogether. The well known practice of rotation of crops in agriculture is the means adopted to prevent a similar condition and we cannot be sure of retaining a cover crop unless we take steps to use it. By digging the cover into the soil at regular intervals we can avoid this staling and keep the cover actively growing. In addition, we can, by so doing add to the soil considerable quantities of organic matter which we have seen is essential for the maintenance and improvement of soil fertility. All the leguminous cover crops are valuable in this connection and to those already referred to we may add those with an erect type of growth, namely, *Tephrosia candida* (Boga medeloa), the species of *Indigofera* and of *Crotalaria*. It is necessary to emphasise that the manurial benefits of green cover plants are not fully secured until they are buried and incorporated in the soil and that the mere growing of a cover crop is insufficient to improve fertility.

It is not the actual amount of chemical matter added to the soil which increases fertility but the combination of factors already referred to. In this connection the question is often asked whether green manures can be used to entirely replace artificial manures. Unless the supply of green substance is very abundant the humus in the soil may, if used alone, become depleted at a greater rate than it can be replaced. By the addition of a proportion of artificial manure the call on the humus can be better regulated and the beneficial results be spread over a longer period of time. It is considered by those who have studied this question that a combination of artificial and green manures gives better results than a similar quantity of each if applied separately.

Having decided that cover crops should be utilised as green manures we have now to consider the time when such crops should be dug into the soil and the best method of doing this. It is in this connection that opinions differ and it is the writer's opinion that no uniform system will meet all conditions.

In the case of all the non-woody types of cover plants the best time for incorporating them into the soil is before the flowering period. During flowering there is a depletion of the nitrogen content in the leaves and shoots of cover plants so that the full quantity of organic nitrogen would not be received by the soil. In the case of the shrubby or woody types there should be periodical lopping of the young green shoots and the incorporation of these into the soil. When these plants have become distinctly woody they should be uprooted and new plants put in to

replace them. It is not advisable to bury the woody parts as it has been found that if we bury the woody material along with the green matter there is a retardation of the rate of nitrification of the whole and in addition there is the risk of disease arising on the buried woody material spreading to the rubber. With regard to non-woody covers, experiments have shown that if the cover is cut into narrow strips it can be pushed into the soil and covered during what is known as envelope-forking. This method could also be adopted with the herbaceous loppings from *Tephrosia* (Boga), and *Crotalaria* or any similar shrubby green manure crop.

Another system which has been practised with success has been to lay the loppings, woody or otherwise, in shallow trenches for ten days or a fortnight and then remove the wood from the trench. It was found that the whole of the leaf had separated from the shoots and formed a layer at the bottom of the trench. This was covered with earth previously taken out of the trench and the woody material was laid in lines below the trenches forming a very effective terrace. Such a system would, in the writer's opinion, prove suitable in all areas where Boga or *Crotalaria* has reached the woody stage and is due for removal.

The desirability of using artificial fertilisers along with green manures has been referred to and questions are often asked as to how this can best be done when covers are already well established. The artificial manure can be broadcasted over the cover just prior to envelope-forking or be mixed with the leaf-mould in the trenches at the time the woody material is being removed or alternatively it can be run along the grooves after envelope forking. The purpose of all manuring is to secure the incorporation of the manure in the soil and any method which will enable this to be done may be adopted. This appears to the writer to be a problem for practical men conversant with the conditions existing on their respective properties and no hard and fast rules can be laid down as to the best method to adopt. The conditions on rocky slopes are very different from those on flat land, and hard kabooky soils cannot be dealt with in the same way as soft loams. Each condition should be studied and the method made to fit the case.

Conclusion.

In conclusion, it is necessary to refer to the problem of root diseases of rubber in association with cover crops. There can be little doubt that the growing of cover-crops sometimes encourages the development of root diseases and one is frequently confronted with cases where the mycelium of fungi such as *Fomes lignosus* and *Poria hypobrunnea* have spread from one tree to another along the roots of cover-crops. The cover-crop may not

itself be affected by the fungus but may serve merely to facilitate the spread from one point to another. On the other hand the writer has frequently observed cases of actual attack of cover-crops of the woody type *Tephrosia* and *Crotalaria* by *Fomes lignosus* in close association with affected rubber trees.

While recognising the possibility of spread of root disease in this way the writer is of the opinion that if such occurrences are treated in the way advised for all attacks of root diseases no great extensions of diseased areas are likely to result. Up to the present time experience has shown that such areas form a very small proportion of the areas at present under cover crops and it would, therefore, be a mistake to deprive oneself of the undoubted advantages to be secured from the growing of cover-crops because of the possible danger of a small addition to the amount of root disease which may arise.

Discussion.

His Excellency thanked Mr. Mitchell for his interesting address and invited discussion on the subject.

Mr. A. N. Philbrick remarked that there was an important difference between burying green manure desiccated and green manure moist.

Mr. A. W. R. Joachim stated that laboratory experiments had shown that nitrification would be delayed if green manures were dried before incorporation with the soil. As a matter of fact, less nitrates were found at the different stages of the decomposition, in soil in which dried material had been buried, than in the control. Eventually, however, he expected that the effect would be the same whether green or dried green manures were buried.

Mr. T. Eden.—For a very long time the question of the optimum time for the incorporation of green manure was a matter which could only be settled by purely empirical methods. It was known, for instance, that a crop of wheat turned in green was beneficial, but that dry straw was harmful. Fortunately, the recent works of Richards, Hutchinson, and Rege at Rothamsted has given us a definite criterion of the optimum conditions for the turning in of green stuff. This optimum depends upon two things, first the ratio of pentosan to lignin in the tissue and secondly the nitrogen content. It is well known that young leaves have a higher nitrogen content than old ones whilst if the tissues get old and woody, the pentosan-lignin ratio falls with consequent detrimental effect on rotting and general soil conditions. This explains why buried wood gives such bad results.

To use the green manure early when chemical conditions are highly satisfactory may, however, involve a loss of crop and consequent loss of humus, or it may clash with the optimum conditions from the point of view of the management of the crop and of the rubber or tea, as the case may be.

There is, however, something to be said for attempting to get the chemical optimum and the managerial optimum to coincide so that practice and science may join in the improvement of green manure cultivation. In conclusion it may be mentioned that a study of green manures used in tea cultivation from this point of view, forms one of the researches which I propose to undertake and which has been approved by the Board of Management of the Tea Research Institute.

Mr. Wanigasekere stated that it was customary among a number of planters on rubber estates to manure their leguminous crops with what was called a complete mixture. That was a manure mixture which contained phosphoric acid, lime and potash in an available form. Their main object was not to increase the organic matter of the soil but to keep the nitrogen contained in the soil within certain limits because it had been demonstrated very conclusively that with intense cultivation they were losing the nitrogen at an alarming rate.

He (the speaker) wished to know whether it was economical to manure leguminous green manure plants which were planted on estates at present.

Major Oldfield said that burying green manure in drains kept it always moist. Possibly one of the chemists might be able to tell them about the benefit or otherwise of that system. Stag-headed rubber, he thought, was best and quickest cured by terracing round the tree and feeding it with green manure. He agreed with Mr. Dias as to the possible yield of some of the *Desmodiums,* but he was a firm believer in the larger type provided it was kept under control and not permitted to grow too near the tree. He particularly referred to what he thought was *Desmodium.*

Mr. Alston stated that he did not think *Desmodium* grew so large as described by Major Oldfield. From his description of the leaf it should however be *Desmodium.*

Mr. M. Park.—There is a very cheap method, and that is by cutting Vigna, turning it over and allowing it to rot, I understand that can be done for one or two rupees an acre.

Mr. Stockdale.—Thought with regard to the point raised by Mr. Wanigasekere that if leguminous cover crops were given nitrogen in the form of manure, they would "grow lazy" and cease to make use of the nitrogen in the air if supplies in the soil were made available in quantity. On the other hand, any such manuring should be limited to the period in which it would become available and useful. The work which Mr. Joachim had done so far tended to indicate that the maximum nitrification took place between 6 to 8 weeks from the time of application, and that after a period of 6 months it was practically complete, so that after that time any cover crop would have to look for its food from sources other than manure. It was quite possible that a small application of manure, such as a general mixture, would be generally beneficial. In regard to the question of the burial of green cover crops, a good deal of work had been done in America some years ago, and it had been definitely shown that from a practical point of view, it was more advantageous to bury green manures green than to let them dry up and bury them after they had wilted.

His Excellency then requested Mr. Gordon Pyper to initiate the discussion on behalf of the Kandy District Planters' Association on "The use of artificial manures forked into the soil in the control of *Oidium.*"

Mr. Pyper said that his district had brought up the question of attack by Oidium before the Department of Agriculture three years previously and had been told that there were no direct means of controlling the disease. Certain authorities had recommended the forking of manures into the soil as a cure, but the same authorities subsequently declared the manures were of no use. The disease was devastating a number of trees in the Kandy District and he wished to know whether any data were available as to the efficacy of forking as a preventive of the disease.

Mr. M. Park.—It is difficult to answer this question without going into the reasons, either for or against, the application of artificial manures to rubber affected with *Oidium* leaf disease. It is obvious that a manure applied to the roots is likely to be of little value in controlling directly a

fungus attacking the leaves of rubber. I propose, therefore, to give a brief *resume* of the life-history of the fungus and to point out in what respects the application of manures will tend to be beneficial or otherwise.

Oidium heveae is an epiphyte; that is to say, the fungus lives on the outside of its host from which it absorbs food material parasitically by means of haustoria or small suckers which penetrate into the leaves. No other stage of the fungus is known in the tropics and I should like to emphasise the fact that the fungus is present all the year round on the leaves of its host. It is only when favourabe conditions arise that it becomes noticeable to the casual observer by attacking seriously and defoliating its host. These conditions are of two kinds.

1. Climatic conditions

2. Physiological condition of the host plant. Dry weather favours the production of spores, while wet weather favours its vegetative growth and the germination of spores, and the presence of a strong wind would tend to aid the dissemination of the spores. Weather of this type is found in the early part of the year, in bright dry days and cool dewy nights.

The most favourable condition of the tree for severe attack appears to occur shortly after wintering at the time of the unfolding and expansion of the new leaves.

The occurrence of these two conditions of tree and environment at the same time appears to be the deciding factor in the incidence of severe attack.

The effects of the disease appear to be cumulative; the periodic defoliation and refoliation act as a drain on the resources of the tree and must in time result in its loss of condition or degeneration.

In what way then may we expect advantages from the application of quick acting manures in counteracting the disease ?

It is possible that the application of manures will hasten the leaf production and thereby lessen the period of susceptibility.

Manuring will be of great value in assisting the tree to regain its losses, so to speak, and to make up for the drain on the resources of the tree caused by the replacement of diseased and fallen foliage.

On the other hand, application of manures may stimulate the tree to such activity that it may be defoliated twice during the period of virulent attack.

The only real control of the disease is to be obtained by spraying. Since it has been observed that the fungus is present on the leaves all the year round it would appear that the most favourable time for attempting to control it would be during the period in which it is least active. Spraying with a lime-sulphur mixture, such as *Sulfinette*, would appear to offer the greatest promise since the fungicidal nature of the gases involved from such a mixture obviate the necessity for a perfect covering of sprayed fluid. It would be of great value if spraying tests could be carried out on estates which suffer severely from the attacks of this disease.

His Excellency the Governor said that they were very grateful to Mr. Park for his explanation and for the advice he had given. He believed Mr. Aubrey Clarke had something to say on the subject.

Mr. Aubrey Clarke said that the treatment carried out in Uva for Oidium attack was on the same lines as suggested by Mr. Park. The growing of Vigna, he thought, increased rather than checked the disease. Mr. Mitchell had not dealt with that subject. He had referred to the relation of cover crops to disease but only to root disease. Could Mr. Mitchell tell them whether manuring was helping in any way to check disease ?

Mr. Mitchell said that the same question had been put to him in regard to an estate under Vigna which suffered severely from Oidium, but the enquiries he had made did not show that the disease was worse in the areas under Vigna than in the clean weeded areas. He himself did noth believe that there was any connection between the growing of Vigna and *Oidium*. Nitrogenous manures did not so much prevent disease as resuscitate the tree for the loss it had sustained. The Rubber Research Institute was investigating the matter, but how long it would take them to come to a definite conclusion he could not say. The disease was proving very serious in the Matale, Kandy and Uva Districts, and to a lesser extent in Kalutara, while, curiously enough, the Kelani Valley was only slightly affected.

Mr. Stockdale said that in the last two years the disease had become very common in Java and there had been some very disquieting reports from the drier parts of the country. As Mr. Mitchell had pointed out, the disease was under special investigation in different aspects both by Mr. Park and Mr. Murray of the Rubber Research Scheme. He did not think it was possible at the present time, from the information available both from the Estate Superintendents and various scientific officers occupied with this problem, to say with any degree of confidence whether manuring was going to have any control on *Oidium*.

The point raised by Mr. Clarke as to whether there was any connection between the growing of Vigna and *Oidium* attack was one that had not been raised before. It may be that because *Oidium* had become particularly noticeable last year and as it synchronised with the greater use of Vigna, there was a resulting association between the two in the minds of some people. He personally could see no reason why the growing of Vigna should in any way increase the attack of *Oidium* on rubber.

Mr. Murray said that extensive manuring with cyanamide had seemed in the case of an estate in Kalutara to reduce the intensity of *Oidium* attack. This was not in any sense a controlled experiment, but in the case of a particular field, when the manure was applied too late, that is, after the wintering period, it had had no effect at all. In another experiment the Superintendent of the estate manured six or eight trees right in the middle of a very bad field, with cyanamide at the rate of 2,000 lb. per acre, and although the rest of the field was attacked severely by the disease, he could detect no diseased leaves on the manured trees. It seemed possible, although there was no evidence, that the application of nitrogenous manures might have a structural effect on the leaf. It was possible that it resulted in a thickening of the cuticle which made the leaf more resistant to disease. If the manure merely stimulated the production of new leaves, it was rather difficult to explain the effects he had mentioned. The application of manure to such a large extent, however, was not feasible as an estate proposition. It seemed to him that experiments on the lines he had suggested were called for.

Mr. Westrop mentioned that out of about 16 estates that had used synthetic urea, only one had reported unfavourably, the rest had all recorded favourable results. The manure, however, was intended more for *Phytophthora* than for *Oidium* attack: it would appear, however, that its application might be beneficial in cases of attack by the latter.

His Excellency thanked all those who took part in that interesting discussion.

(The discussion then ended.)

His Excellency then called upon Mr. T. H. Holland to read his paper entitled "Some notes on the budding of rubber and the transport of bud-wood."

Some Notes on the Budding of Rubber and the Transport of Bud-wood.

T. H. HOLLAND, Dip. Agri., Wye.,

Manager, Experiment Station, Peradeniya.

Method of Budding.

THE actual method of budding in the nursery has now been standardised on the Station and, as the procedure has generally produced successful results, the method may be briefly explained.

A gang of four men makes for easy working—they will be called A, B, C and D. A is provided with a cloth, a piece of slightly curved rectangular galvanised tin measuring $\frac{3}{4}$ in. by $1\frac{1}{2}$ in., and a budding knife. He cleans the lower 3 inches of the plant with the cloth and places the piece of tin on the side of the plant to be budded as near ground level as is convenient and possible. He then makes a horizontal cut with his budding knife across the top of the piece of tin and a vertical cut down each of the sides. With the bone end of his budding knife he then prizes out the flap of bark formed by the three cuts which is still attached at its lower side.

B, who should be the most skilled man, is solely occupied in selecting and cutting out buds from the bud-wood. He is provided with a budding knife and a piece of tin cut slightly smaller than the one being used by A and with a round hole cut in the middle to enable the bud to be seen when the piece of tin is placed in position. Having selected a bud he holds the piece of tin over the place with his left thumb so that the bud is visible through the hole and with his budding knife makes a horizontal cut across the top of the piece of tin and a vertical cut down each side. He then removes the piece of tin and with a deep upward cut starting at least $1\frac{1}{2}$ inches below the bud cuts off a chip of wood containing the patch of bark and the bud. Holding this chip carefully by the edges with his left hand he then prizes out the bud patch with the bone end of his budding knife. He trims the lower edge of

this piece into a rounded shape to distinguish it from the flat upper side and to avoid the possibility of putting the bud on upside down. Alternatively the piece of tin might be made rounded at the bottom side and cuts made all round this at once, but it is somewhat easier to carefully remove the bud patch from a small chip of wood than direct from the branch. Care must be taken not to touch the cambium.

C takes the buds from B and, holding them only by the edges places them right way up behind the flap of bark left by A.

D is provided with a number of strips of any strong and easily tearable cotton material or calico $\frac{3}{4}$ in. wide which have been previously dipped in a heated mixture of 1 part "Entwas," 2 parts resin, and 1 part tallow. These waxed strips are for convenience rolled round short pieces of stick. As soon as C has inserted the bud C and D bind it tightly round (covered by the flap of bark left by A) with one of the strips of waxed cloth. This binding should completely cover the bud patch. Such a gang can bud up to 200 plants in a day.

Conditions Affecting Success.

Apart from the skill of the workmen there are a number of conditions which affect the success of budding operations.

(1) **Conditions of the Bud-wood.**—This is of great importance. If the bud-wood is too mature or for any reason dried up it will be impossible to successfully remove the bud which will probably remain attached to the branch. The best results can be obtained from bud-wood which is still green or has only recently turned brown. In 1927 a separate record was kept of the successes obtained from the use of green bud-wood and brown bud-wood; 15% more successes were obtained from green wood. This was possibly not a fair test as the brown wood included a good deal of bud-wood which arrived from estates in poor condition. It is clear, however, that green wood can be used and that chances of success are at least as great as with brown wood. The best bud-wood is obtained from pollarded trees and, at Peradeniya, it is necessary to pollard the trees at least a year before the bud-wood is required. It is probable that the manuring of the pollarded trees will both increase the rate of production and improve the quality of the bud-wood. Any mixture used for this purpose should include a fair proportion of a quick-acting nitrogenous manure.

It is also quite possible that, given equal conditions, buds from one particular tree would always give a greater number of successes than buds from another tree. The following figures are

taken from budding done on August 1st-6th, 1927, under approximately similar conditions.

No. of mother tree.		No. of buds put on.	Percentage of success.
P 5	...	154	70
P 7	...	134	70
P 12	...	133	56
P 41	...	137	56

In this case P 5 and P 7 are distinctly healthier and more vigorous trees than P 12 or P 41.

(2) **Weather conditions.**—As in most agricultural operations, the element of luck is a potent factor. A prolonged dry period following budding is fatal to a large percentage of successes. Very wet weather is also undesirable. Light showers and a fairly humid atmosphere are the desirable conditions and it is not possible to predict exactly when such conditions will occur. In a normal season September, March or April should be good months for budding.

Between August 1st and August 6th, 1927, 801 plants were budded in the nursery. The rainfall was:—

August 5th,	...	0·13 inches
,, 7th,	...	0·23 ,,
,, 10th,	...	0·11 ,,
,, 11th,	...	0·10 ,,

After this no rain fell for two weeks.

From this budding 59½% successes were obtained. On October 7th, 1927, 122 plants were budded. There was no rain at the time of the budding but from October 11th onwards heavy rain fell every afternoon. From this budding 75% successes were obtained. From this it would appear more important that rain should fall in the period succeeding the budding, but the condition of the bud-wood and other factors exercise such potent influence that it is not possible to make an exact comparison between one set of weather conditions and another.

(3) **The Vigour and Age of the Stock.**—The influence of stock on scion in rubber budding is a problem that is still under investigation. It is obvious however that a vigorous free growing stock is desirable.

In budding done between August 1st and August 6th, 1927, the following percentages of successes were obtained from different stocks:—

Stock.		Percentage successes.
P 7	...	73
H 2	...	69
P 5	...	68
P 12	...	58
P 41	...	50

Varying numbers of buds from different trees were budded on to these stocks so that the comparison is not a reliable one. It is to be noted however that the stocks of P 7 and H 2 have always stood out in the nursery as vigorous healthy plants and this appearance is reflected in the percentage of successes obtained by their use as stocks.

With regard to age, in the early days of rubber budding it was stated that it was necessary for the bud-wood and the stock to be of the same age. Mr. C. E. A. Dias has, by his successful budding on to trees of all ages, demonstrated that this condition, though doubtless desirable, is by no means essential.

Examination of Bud Patches.

After 14 days the binding is removed, the flap of bark that was left at the time of budding is broken off and the bud patch is examined. This is done by making a light scratch with the point of a pen knife. If the weather is very dry when the first examination is due it may be advisable to delay the removal of the binding for a few days.

On Mr. C. E. A. Dias's estates the bandages are not removed for 20 days and another 6 days are allowed to elapse bofore the flaps are broken off and the first examination made.

The second examination is done 14 days later, i.e., 4 weeks after budding. If the bud patch still shows green above and below the bud the plant is a success.

Cutting or Breaking off and Planting out.

Until it is desired that the bud shall shoot out the plant can be left alone and the bud will remain dormant.

Plants budded on the Experiment Station in August, 1927, were not cut off till November—3 months later. In this case the plants were cut off 6 inches above the bud patch and then planted straight out in the field. Major H. Gough in his book "*Practical Budgrafting and Seed Selection of Hevea Brasiliensis*" recommends, instead of cutting off, ringing the plant 5 or 6 inches above the bud patch and at the same time breaking off the plant about half way between the ground at the top. It is presumed that the effect of such a procedure is rather more gradual than cutting off direct, otherwise it is hard to see the advantage of the method. Mr. C. E. A. Dias states that he has adopted Major Gough's method and finds it more successful than cutting off.

Major Gough recommends planting out when the shoot from the bud is between half an inch and three inches long and then sawing off the stock at the ringing place. If the shoot has grown too long he recommends cutting it back to half an inch. In 1922 some plants with shoots one to two feet long were planted out on the Experiment Station and all these shoots died back. An alter-

native method is to plant the stump out directly the top has been cut off without waiting for the bud to sprout. This was done with 400 stumps planted out in November, 1927. The subsequent sprouting of the buds was very irregular. Three months after planting some plants had shoots 1½ ft. high, others 2 inches high, some were just starting to sprout, and some had not yet started though the bud patches were still green. Nearly all these buds were put on during the first week in August so that the irregularity was probably due to the different times taken for the stocks to get properly established. Fifty-two stocks out of this four hundred died but there was no instance of the bud dying and the stock surviving. The buds were all shaded from the sun after planting out.

Budding in the Field.

No budding in the field has as yet been done at Peradeniya.

Mr. C. E. A. Dias has found budding in the field to be more successful than budding in the nursery. He states his experience to be that shoots from plants budded in the field grow more quickly and uniformly than those on plants budded in the nursery and transplanted. Mr. Dias recommends planting 3 seeds in a hole and budding on to the most vigorous of these seedlings when it is about 3 feet high. In place of failures another bud can then be put on to the next most vigorous plant. When one success has been obtained the extra seedlings can be removed.

Transport of Bud-wood.

Bud-wood has been received from other countries packed in two ways.

In a consignment received from Java each shoot was separately wrapped in damp jute hessian and the hessian was in turn surrounded by a plantain sheath. These bundles were packed in damp sawdust in a wooden case.

Fifty per cent. of successes was obtained from this bud-wood though weather conditions were most unfavourable—no rain falling for 10 days after budding.

Another consignment of bud-wood was received from the Federated Malay States. In this case the shoots were wrapped in jute hessian and packed in dry charcoal in wooden cases. This bud-wood arrived in a very dry state, the buds peeled badly and only sixteen per cent. of successes was obtained. In this case again weather conditions were unfortunate but not more so than in the case of the Java consignment.

Discussion.

Mr. C. E. A. Dias stated that he had very little to add to what Mr. Holland had said. There was, however, one point that he had to add and that was that there was a difference between budding in the nursery and budding in the field. He had tried both and found that budding in the field was far more successful than budding in the nursery. Where a bud was put on in the field, it generally shot out in 2 weeks or a month except a few trees. Mr. Dias then dwelt on the difference in growth of buds from different mother trees.

His Excellency the Governor thanked Mr. Dias for the information he had given the Conference. He had had the advantage of seeing Mr. Dias's experiments on his estate, as also Mr. Holland's at the Experiment Station, Peradeniya. He hoped that anybody interested in the matter would not fail to profit by their being at Peradeniya to pay a visit to the Station and see the work that Mr. Holland was doing. It would also be of advantage to them if they call on the ever hospitable Mr. Dias and inspect his experiments.

He believed that there was a feeling of doubt among some rubber planters as to the efficacy of bud-grafting on a large scale. If that doubt existed among the members of the Conference he hoped that it would be ventilated, so that some of the difficulties might be considered. He believed Mr. Oldfield was among the doubters.

Major Oldfield.—No, Sir. I think Your Excellency is referring to a conversation we had the other day, but I did not attempt to cast any doubts.

Continuing Major Oldfield stated that the point he had stressed was the importance of seed selection. He held the view that by bud-grafting one could extend the existing plant, but that one could not improve its yield. The only method of improving the yield was by seed selection and the gradual elimination of poor yielders. He admitted that bud-grafting was a short-cut in the preliminary stages of that work, but his point was that so far as other plants were concerned experience pointed to the possibility by budding of increasing the supply of good yielders, but not of improving their yield. By seed selection the strain was improved and this gradually resulted in higher yielders than at present.

Mr. Stockdale.—Major Oldfield has raised a very important point, which, I think, the industry should consider very carefully. The system of budding has, I think, in Ceylon, been looked upon as being somewhat difficult, and in consequence there has not been that same amount of experimentation done on the part of estates as there has been in the Dutch East Indies, where there are quite a number of estates planted with budded plants. Many of such plantings are quite pure without any admixture of seedlings. In others where the planters were not quite convinced that budding was a commercial proposition, seedlings were planted in alternate rows. From information that I have, from last year many of the larger estates have decided to do away with their alternate rows of selected seedlings since they have had indications which they thought were sufficient to warrant the planting of the whole of their areas with budded rubber. Similarly recently, the Dunlop Rubber Company in Malaya has undertaken to bud an area between six and ten thousand acres of rubber so that they are convinced of the possibilities of budding. On the other hand, there is yet no data available as to the effect of tapping of budded rubber. We have information and certainly there is a decided feeling among rubber planters that the bark of budded plants is thinner than the bark of seedlings, and the question arises whether the renewal of that bark is going to be as good as the renewal of

bark on seedlings. That is a very important question as far as Ceylon is concerned, because our barks are generally thinner and their renewals not so good as they are in other rubber countries, and consequently this is a factor which we must not lose sight of. It is quite conceivable that even for Ceylon budding may be a commercial proposition but at present it should only be considered at the moment as a matter for extensive experiment.

Now to return to the point which Major Oldfield raised: the question of increasing yields by means of seedlings. It is perfectly true that if one has a mixed population of seedlings of which one knew the origin, one might get a certain number of high-yielders. But this is being done on estates now where they pick out a number of high-yielders, and it is readily possible now to isolate such trees and procure seeds from only high-yielding trees. For instance, the old rubber at Heneratgoda has recently been tapped for individual records for a whole year. Out of the 900 trees there, 45 have given in one year's tapping a yield of over 20 pounds per tree. Heneratgoda No. 2 is still standing top and yielded the equivalent of 49·5 pounds last year even when half the branches had been pollarded for the production of bud-wood. Well, that to my mind is a sufficiently good tree to warrant going ahead and trying to get a pure plantation on a commercial scale or experimentally on estates. There are other trees in Ceylon which are known to give higher yields. I have heard a record of one tree which had given more than 100 lb. for a year. It seems to me that we should isolate these good yielders for budded plantations and test whether they bud true or not and at the same time establish seed gardens of budded material for the production of seed from those particular trees. The only figures we have available in Ceylon at the present time are from the progeny of Heneratgoda No. 2, areas of which have been planted at Peradeniya and Heneratgoda. The Peradeniya figures have shown that even where we only know the parent tree on one side, namely Heneratgoda No. 2. we have got a 40 per cent. increase over other rubber of mixed parentage of the same age. In other words we are able from this selection to increase our yields by 40 per cent. One can easily conceive what that means to an industry that is confronted with the necessity of reducing the cost of production per pound as far as possible.

If, on the other hand, we isolate these trees and use only pure seed, crossing one tree with other grown originally as budded stock, it is possible that we shall get even higher yields, but at the same time I do think it is very desirable that the budding programme should go on simultaneously with the programme of seed selection because the only method of proving the value of the seedlings from any tree is by a detailed analysis of its progeny. One can well imagine how long that would take, considering that the figures for Heneratgoda No. 2 took 15 years to produce. It is easier to proceed along the lines offered by budding if it is proved to be a commercial success in Ceylon. For the establishment of seed gardens with some of the Rubber Restriction Fund money, it is proposed to plant out pure areas of budded plants for seed purposes in isolated areas. I hope shortly to ask estate owners and others to place at the disposal of the Department areas on which such budded stock can be put out for the purpose of raising selected seed for the industry in the future. At the same time, I think that it is very necessary that all high-yielding trees should be tested for their budding capacity. It has been found that in the Straits and Dutch East Indies that several trees do not bud true. There are no figures yet of the yields of budded rubber in Ceylon; a beginning of tapping has begun at Peradeniya this year and figures will be available in the course of this year. Mr. Dias has tapped some of his trees, but I think in the older ones he has not got actual records of their origin. In those days one did not realise the importance of keeping full re-

cords of mother trees and in consequence definite figures are not yet available. I think that whereas seed selection is desirable it is a very long process, and the commercial situation at the present time requires that we should have available both bud-wood and selected seeds as early as possible.

MR. DIAS confirmed what Mr. Stockdale had said on the matter. He said that he had found bark renewal of budded trees quite satisfactory.

At this stage HIS EXCELLENCY thanked all those who took part in the discussion.

Before the proceedings of the morning were brought to a close, MR. R. G. COOMBE said that as they were aware there had been a good deal of controversy during the past year between the respective Mycological sections of the Department of Agriculture and the Tea Research Institute, regarding *Rhizoctonia bataticola;* he wished to know whether Dr. Small had any information to report on the matter.

DR. SMALL, in view of the length of the notes he had prepared, thought that the question might be taken up the first thing in the afternoon session.

(The proceedings of the morning session were then brought to a conclusion).

Tuesday, May 8, Afternoon Session.

HIS EXCELLENCY THE GOVERNOR called upon Dr. Small to open the discussion.

DR. SMALL explained that the notes he had prepared on the subject had been rather hurriedly got together. He thanked Mr. Coombe for the notice he had given him to prepare such notes as he was able to place before the Conference. He then read the following paper:—

It may be recalled that at last year's Conference I put forward new views on the causation of root disease in Ceylon, particularly root disease of woody plants like tea and rubber. I showed that investigation in 1926 had disclosed the presence of a fungus hitherto unrecorded in cases of root disease in Ceylon, *Rhizoctonia bataticola* by name, and that the study of the new fungus had led to certain conclusions. Briefly, the main points were (1) that *Rhizoctonia* was a frequent cause of root disease and as such had to be added to the list of fungi said to cause root disease, and (2) that, when the older and better-known fungus causes of root disease like *Fomes, Poria, Diplodia, Rosellinia* and *Ustulina* were present, the *Rhizoctonia* was not only present at the same time and on the same specimen but was present under such circumstances that it was likely to be the primary or original cause of the disease and the accompanying fungus or fungi to be of only secondary importance. A third point may be mentioned, that I opined (prophesied, if you like) that future investigation would show that the *Rhizoctonia* was present and was concerned in root disease in tropical regions from which it had not been recorded; in other words, that the conditions discussed were not confined to Ceylon. These views met with a certain amount of criticism to which a reply was given in due course. I need not repeat in detail the reasons for the new views on the responsibility of *Rhizoctonia* for root disease, but I should like to make a few remarks on the three points I have mentioned and to deal in the passing with the present position of investigation of *Rhizoctonia* root disease.

To take the first point, that *Rhizoctonia* is a cause of root disease. It has been asserted that *Rhizoctonia* is not a parasitic fungus but is on the contrary a saprophyte which owes its presence in dead or diseased roots to the fact that the roots have been killed or sickened by another agent and so have allowed the *Rhizoctonia* to attack them. An important discovery which has a strong bearing on this point has been made, namely, that *Rhizoctonia* may be found in *living* apparently healthy tea roots. In addition, the supporters of the saprophytic view are flying in the face of the facts. It would be interesting to know how they would interpret the presence of *Rhizoctonia* in specimens of root disease preserved in the Mycological Laboratory of the Department. Its presence cannot be denied, nor can it be ignored: in my opinion, it can be interpreted in only one way. The behaviour of *Rhizoctonia* is not that of a saprophytic fungus.

Those who read the *Tropical Agriculturist* may have noted a short article by Mr. Park in the March number, the title of which is "A preliminary note on a mycorrhizal fungus of tea roots." Mr. Park announces the finding of *Rhizoctonia* in a mycorrhizal condition in tea roots, that is to say—and this point is of great significance—in *living* young roots. The fungus has also been found in apparently healthy older roots taken from apparently healthy bushes.

A mycorrhiza is what has been called a coalition between a fungus and the living tissues of the roots of a plant. The partners in a true mycorrhiza live together in a state of *mutualism* or *mutual tolerance* or *symbiosis* in which the plant helps the fungus and the fungus benefits the plant. The mycorrhiza of tea roots may be a true mycorrhiza, but it has to be remembered that the nature of a mycorrhiza is in dispute, that the fungus has to attack the plant before the mycorrhiza can be formed and that certain authorities hold that the mycorrhizal condition is one of parasitism of the fungus upon the plant root, albeit parasitism of a weak or suppressed kind. Whether the tea root mycorrhiza described by Mr. Park is a true mycorrhiza or not is not yet known, but it may be doubted if it is a true mycorrhiza in the sense that the symbiotic condition is obligate (as in the orchids). Again, symbiosis or living-together has been shown to have become parasitism. It may be asked, therefore, if there are indications that the supposed mycorrhizal fungus of tea roots (we are concerned only with *Rhizoctonia* at the moment) undergoes a change from its supposed mycorrhizal nature, and the following facts have to be taken into account. The *Rhizoctonia* can be found to have killed the roots it has entered and it can be found in and isolated from the larger apparently healthy roots of apparently healthy bushes as if it had passed into them from the smaller roots. It is possible, therefore, that the death of smaller roots followed by the death of larger roots and eventually of the whole bush is a natural sequence of the presence of the *Rhizoctonia*....On the whole, it may be doubted if the behaviour of the fungus is that of a true mycorrhizal fungus or, indeed, of anything but a parasite. On the other hand, it is possible that the plant may hold the fungus in check after it has actually entered the roots and that a balanced condition of mutual tolerance may continue for a long time or even throughout the lifetime of the plant provided that nothing arises to interfere with it and give an advantage to either plant or fungus over the other.

Certain investigations which are in hand are directed towards an increase of our knowledge of the fungus or fungi which can be found in the young roots of economic plants in Ceylon. It is felt that such knowledge may throw valuable light on the conditions of nutrition of the roots of

tropical plants and hence on the root disease problem. It is a matter of great interest that Dr. Steinmann of the Tea Proefstation in Java has found simultaneously, and is engaged, I hope, in a study of, the mycorrhiza of tea roots. Meanwhile, the presence of *Rhizoctonia* in very young tea roots, whether in the form of a true mycorrhiza or not, is in favour of, rather than against, my contention that *Rhizoctonia* has more to do with the causation of root disease in Ceylon than the fungi which have been blamed in the past.

The complaint has been made that the parasitism claimed for *Rhizoctonia* is unsupported by experimental evidence. That complaint is not well-founded and, in any case, it cannot be urged as strongly as formerly. Certain results have been attained in experimental inoculations of various seedling plants, an account of which will be published in due course, and emphasis may be laid on the discovery that seedlings exposed to attack have to be examined with care and minuteness. A merely casual or external examination may lead to the erroneous conclusion that the fungus has not attacked or entered the roots of the experimental plants, especially if the plants show only signs of slight lack of condition and are not killed or palpably diseased. In other words, plants that do not look like positive cases of infection may prove and have proved to be infected after all.

The second point is that, in cases of root disease in which more than one fungus is present, the *Rhizoctonia* is invariably present and that it occurs under such circumstances that it must be regarded as the primary parasite and the accompanying fungus or fungi as of only secondary account. This view involves a revision of ideas propagated and held in the past regarding the harmfulness of root fungi like *Fomes, Poria, Diplodia* and *Ustulina,* and it is only to be expected that it should meet with criticism and opposition. Dr. Gadd has asserted, for instance, that fungi like *Fomes* and *Poria* must be parasitic because their outbreaks are controlled by the measures recommended for dealing with them, namely, trenching and stumping, and it had to be pointed out that that was no argument for the simple reason that trenching and stumping have not been proved to have any effect on the incidence of disease supposed to be caused by the fungi in question and that it is doubtful if those measures do really control the fungi or have lessened the relative amount of root disease in recent years.

Mr. Petch has lately brought forward evidence of the parasitism in experiment of the older and better-known fungi. The case for these fungi, *Fomes, Poria* and others (there is no mention of *Diplodia*), seems perfectly good until it is remembered that *Rhizoctonia* is found to be present so consistently in cases of supposed *Fomes* and other root disease that one is justified in being suspicious of its presence in the cases quoted. In the past it was not looked for or even suspected to be present because investigation had not yet disclosed the necessity of looking for it. It is therefore possible, even likely, that the cases quoted by Mr. Petch are not as good and reliable as they seem. But there is another point against Mr. Petch's fungi. He has invited planters to experiment with them and has assured them that it is an easy matter to get results which show that *Fomes, Poria,* etc. can cause root disease, but he has forgotten to mention the probability of the presence and influence of the *Rhizoctonia* and the consequent necessity for making certain that the *Rhizoctonia* is not vitally concerned in what are supposed and meant to be simple one-fungus experiments with *Fomes, Poria,* etc. Again, attention may be drawn to the fact that *Fomes, Poria* and other fungi have been used in experiment at Peradeniya in the manner he suggests and that the promised results have not accrued. In fact, it has been found that *Fomes lignosus* and *Poria* are parasitic only as secondary agents, that is to say, that they have attacked only plants already attacked

by *Rhizoctonia*. I am therefore doubtful of Mr. Petch's invitation to planters to carry out root disease experiments with *Fomes, Poria,* etc., and more than doubtful of the promised results.

On the other hand it can be said that another year's careful examination of specimens of root disease sent to the Mycological Laboratory for report has not provided any reason for departure from the position I have taken up, that, of the fungi associated with root disease in Ceylon, the *Rhizoctonia* is the primary and basic cause of disease and the other fungus or fungi that may be present—they are often absent—are secondary in importance. This view is receiving a certain amount of support from other mycologists, and I shall not be surprised if it receives more support in the future. I hope that other mycologists will experiment with *Fomes* and *Poria* and other root fungi as well as with *Rhizoctonia.*

My third point deals with the suggestion that *Rhizoctonia* is present and is concerned with root disease in regions from which it has not been reported. Support is lent to my views by the recent finding of *Rhizoctonia* on rubber and citrus (pomelo) in Malaya, on tea, rubber and *Albizzia* in Java, on rubber in South India, on rubber, citrus and other plants in Uganda, on *Acacia* in Kenya, on *Eucalyptus* in Southern Rhodesia, on cotton and citrus in the West Indies, and on *Sesamum* in Burma. The fact that other mycologists are now finding *Rhizoctonia* does not mean that they are in agreement with my views regarding its responsibility for disease, but it does mean a gratifying amount of interest in the root disease problem in general and *Rhizoctonia* in particular, an interest which ought to lead to an extended investigation which ought to lead in turn to a more complete knowledge of root disease and its causes than we possess at present and therefore to a truer point of view. Certain Ceylon critics affect to ignore *Rhizoctonia* or to pass it over as a ubiquitous saprophyte, an attitude which is not being adopted by other mycologists and which is already being shown to be wrong.

His Excellency the Governor.—We are all very much obliged to Dr. Small for the interesting notes. I think Mr. Petch would like to offer some remarks.

Mr. Petch said that he had not the opportunity of knowing what Dr. Small was going to say and his memorandum had been written without a knowledge of one or two points brought forward by Dr. Small.

Continuing Mr. Petch said:—

Amid the flood of literature on *Rhizoctonia bataticola,* one is apt to lose sight of the one cardinal fact, namely, that there is as yet no evidence that *Rhizoctonia bataticola* can be parasitic on woody plants. Until that is proved, all discussions as to priority of attack are pointless.

In the first number of the *Tea Quarterly,* I summarised the experimental data which have been considered to prove the parasitism of *Fomes lignosus, Ustulina, Poria,* and Brown Root disease. If a root attacked by *Fomes* is buried in contact with the roots of a rubber tree it is more than an even chance that the tree will be attacked by *Fomes* and die. That cannot be done with *Rhizoctonia bataticola.* Dr. Small has stated that *Rhizoctonia bataticola* does not spread by contact. (Trans. British Myc. Soc., X., p. 290).

Consequently the evidence in favour of the parasitism of *Fomes lignosus, Poria,* and Brown Root disease is much greater,—expressed mathematically, is infinitely greater,—than that in favour of *Rhizoctonia bataticola.*

As I have previously stated, anyone who pleases can demonstrate the parasitism of Poria on tea by burying a root infected with Poria in contact with the roots of a tea bush. Take an apparently healthy field of tea, select

a dozen bushes in different parts, and bury a Poria-infected root near each. If Poria does not exist on the estate, we shall no doubt be able to supply the material.

After six years' work on the subject, Dr. Small has not been able to kill a woody plant by means of *Rhizoctonia bataticola*. I understand that he has not yet been able to secure a successful infection by inoculation. It seems to me that Dr. Small might now consider the alternative,—that *Rhizoctonia*, in general, is saprophytic.

The arguments put forward in support of the parasitism of *Rhizoctonia bataticola* may be summed up as follows :—

(1) It is found on the roots of dead plants of all kinds. That, to a mycologist, should certainly suggest that it is chiefly saprophytic.

(2) The fungus is a slow grower, and consequently it is difficult to obtain experimental proof that it will kill a tree. But when we seek for evidence that the fungus is a slow grower, we find that it is a slow grower because it takes a long time to kill a tree. That seems to me to be arguing in a circle, and it assumes the facts to be proved. It should not be difficult to devise experiments which would show the rate of growth of *Rhizoctonia bataticola* in, say, tea wood. All the evidence we have at present is that *Rhizoctonia bataticola* is a rapid grower. It grows rapidly in culture, which again suggests that it is saprophytic. It will convert sweet potatos into a black charcoal-like mass, that is, it will permeate them with mycelium, within two months, which again shows rapid growth. Shaw inoculated six jute plants with *Rhizoctonia bataticola;* five of them died within eight days. One could scarcely expect anything quicker.

(3) The *Rhizoctonia* is found first in the finer rootlets, and is therefore the primary parasite. Dr. Small states, " It adapts the most natural means of entry into its host, namely the smallest feeding roots.' Few experienced mycologists would agree with the assertion that entry *via* the smallest feeding roots is the most natural means of entry of a root disease fungus.

None of the observations recorded by Dr. Small is at variance with the hypothesis that *Rhizoctonia bataticola* is a widely distributed saprophyte which grows on woody plants only after they have begun to die from some other cause.

On the other hand, his hypothesis that *Rhizoctonia bataticola* is the primary cause of all Ceylon root diseases does not fit in with the well-known facts that in Ceylon stumps serve as centres of root disease, and that most of our root diseases spread in circles by contact with diseased roots.

I most strongly advise planters not to abandon the present methods of removing stumps and trenching for root disease, because of a hypothesis which is not supported by any valid scientific evidence.

Mr. Park has put forward another view of *Rhizoctonia bataticola*. Some years ago he obtained evidence that tea has a mycorrhiza. A mycorrhiza is an association of a fungus with the root of a plant, and it is generally believed that the association is of mutual benefit. I hope that Mr. Park will be able to follow up this idea, and will give us a scientific account, with photographs of sections of the roots, showing the type of mycorrhiza.

Mr. Park thinks that the fungus of this mycorrhiza is *Rhizoctonia bataticola*. That would account for the presence of the latter on the roots of dead or dying trees. It seems rather a tall order to believe that the same fungus enters into mycorrhizal association with so many different plants, but it is not impossible.

Under normal conditions the host plant and the fungus of the mycorrhiza live together in harmony, but the view is held by some investigators that, if

the plant encounters adverse conditions, the fungus may become parasitic and kill it. I don't quite see why, if the plant is dying because of adverse conditions, e.g., drought or lack of reserve food at pruning time, the fungus should be regarded as parasitic because it begins to grow vigorously on the dying plant.

However, let us consider the normal case of a healthy tea bush.

On the mycorrhizal theory, the fungus and the tea bush are living in harmony. An adverse condition, in the shape of *Poria hypolateritia,* attacks the plant on the upper part of the root; and under that condition the mycorrhizal fungus, *Rhizoctonia bataticola,* begins to invade the main roots of the bush. Which is the disturber of the peace ?

It appears to me that, if Mr. Park's theory is correct, it knocks the bottom completely out of all Dr. Small's contentions.

Continuing Mr. Petch said that Dr. Gadd who took up the question last year was unable to be present at the Conference. However, there were some notes prepared by Dr. Gadd, which he would read :—

"During the last year or more, considerable attention has been paid, in Ceylon, to the fungus known as *Rhizoctonia bataticola.* At the last Agricultural Conference, Dr. Small expressed the view that *Rhizoctonia bataticola* must be regarded as 'the only parasite of present importance in the causation of root disease and its secondary results.'' I opposed this view then and in a later criticism, on the grounds that a simpler and more feasible explanation of Dr. Small's observation can be given, viz., that the fungus in question is merely a common soil saprophyte. Since then Mr. Park has stated that *Rhizoctonia bataticola* is a mycorrhizal fungus, i.e., it lives in association with roots of vascular plants which normally are benefited in some way by the presence of the fungus. Thus, we have three conflicting views :—(1) The fungus is definitely harmful in that it causes multitudinous disease; (2) the fungus is not harmful; and (3) the fungus is possibly beneficial to the plant.

"To the layman and practical planter such a position is decidely unsatisfactory, particularly as the question has a direct bearing on the treatment of root diseases. If Dr. Small's views are correct, stumping and trenching, to control certain root diseases in Ceylon, are valueless and a waste or energy and money.

In a recent article published in the *Transactions of the British Mycological Society,* Dr. Small appears to withdraw these claims.

Dr. Small : May I interrupt, Sir? That paper was written four months before my conference paper delivered in March last year.

Mr. Petch : When did you correct proofs.

Dr. Small : I did not get proofs at all.

"The presumed parasitic status of certain root fungi has been doubted mainly because *Rhizoctonia bataticola* has been found in association with them. These root fungi undoubtedly include the one known as *Rosellinia arcuata* which for many years has been regarded as an important parasite of tea. The assumption is that *Rosellinia* could not successfully attack the plant without a previous attack by *Rhizoctonia.* In other words, *Rhizoctonia* is the primary parasite without the work of which *Rosellinia* would be unable to attack.

"Recently I have had excellent opportunities of studying the fungus *Rosellinia* in the field and laboratory, and have carried out experiments to determine its parasitism to tea. To my knowledge, no previous experimental proof has been published, and as the experiments have a direct bear-

ing on the subject under discussion, I propose to refer briefly to them here. A full description will be published, I hope, in the next number of the *Tea Quarterly*.

"In each of the three experiments carried out, the tea seedlings which were inoculated with *Rosellinia* died two months later. No trace of *Rhizoctonia bataticola* could be found on any of the seedlings so killed, although Dr. Small has stated that ' In Rosellinia-cum-Rhizoctonia on tea, the wood of roots, which have Rosellinia mycelium on the bark, is found to be litterally full of sclerotia of Rhizoctonia." In one experiment, five seedlings were grown in one pot, the central seedling was artificially infected with Rosellinia while the remaining four were used as controls. In this experiment, not only was Rhizoctonia absent from the infected seedling, but there was no trace of it on any of the numerous roots of the surrounding control plants.

"It must, therefore, be concluded that Rosellinia is a virulent parasite capable of attacking the tea without the aid of Rhizoctonia or any other fungus, and under conditions favourable to normal healthy growth.

"It would be out of place here to attempt to remove Dr. Small's doubts concerning the parasitism of the many other fungi which have been regarded by mycologists as the primary cause of definite root disease. It may be advisable, however, to point out that the proof of the parasitic status of *Rhizoctonia bataticola* cannot be advanced by doubting the parasitism of other fungi. Before the parasitism of Rhizoctonia to woody plants can be admitted, satisfactory formal proofs must be adduced.

"Turning now to the second theory to account for the presence of Rhizoctonia on dead root tissues, viz., Saprophytism, it should be remembered that the normal healthy soil has a large population of living organisms including fungi. Waksman found that the soil harboured between 30,000 and 900,000 fungi (spores and pieces of mycelium) per gram, depending on the type of soil and treatment. Many of these require organic material as a source of food supply, so it is not surprising that dead tissues in the soil, e.g., dead roots, are immediately invaded by these soil saprophytes. It is more surprising that Dr. Small should find only one fungus present in many of the roots he has examined, and should base a case for parasitism on such observations.

"*Rhizoctonia bataticola* is admittedly prevalent in all Ceylon soils. This implies that it is well equipped in its struggle for existence, as competition between the millions of soil organisms for food supplies must be very keen. Its ability to invade dead plant tissues rapidly furnishes a simple explanation of its presence on dead root tissues of all sorts under all sorts of conditions. It is immaterial whether a plant dies of drought, lightning, mechanical injuries or organic disease, the root tissues become favourable feeding grounds for the fungus. There is no obvious reason why the mere presence of the fungus should suggest a parasitic habit.

"The newest explanation of the presence of *Rhizoctonia bataticola* in root tissues is that of Mr. Park. He has shown that a number of plant roots, tea in particular, have within their tissues a fungus which is termed a mycorrhiza. Mr. Tunstall has recorded the same thing in India. Mr. Park, however, has carried his investigations further, and has identified the fungus as *Rhizoctonia bataticola*. Whatever the nature of the phenomenon known as mycorrhiza may be, whether it is a case of symbiosis or of mutual parasitism, there is no doubt that the fungi favour in some way the growth of the plants. The growth of a large number of plants depends, to a large extent, upon fungi forming mycorrhiza on their roots.

"The mycorrhizal fungus enters the roots from the soil, and after the death and decay of the roots the fungus passes back to the soil where it lives as a simple saprophyte. That is the usual life history of a mycorrhizal fungus, and there is no reason to suppose that *Rhizoctonia bataticola* as a mycorrhizal fungus has a different life history. It is to be noted, however, that a mycorrhizal fungus normally plays no part in causing the death of the plant it inhabits. If, as Mr. Park's observations indicate, *Rhizoctonia bataticola* lives normally within live roots it is to be expected that the same fungus can be found in dead roots, particularly the finer roots of tea and other plants in which it commonly lives as mycorrhiza. So far, the mycorrhizal theory fits the observed facts. It is entirely opposed to the parasitic theory, but harmonises with the theory of saprophytism in so far as the fungus spends a part of its existence as a saprophyte, and is normally harmless, if not actually beneficial, to the plants it invades.

"Various theories have been suggested by different investigators in an attempt to explain the role of fungi in the nutrition of plants forming mycorrhiza. The one Mr. Park appears to prefer, is the one which supposes a state of equilibrium to exist between the attacking mechanism of the fungus and the protective mechanism of the plant. When this equilibrium is broken down, the fungus becomes parasitic on the plant tissues.

"When we attempt to apply this hypothesis to tea, we immediately meet a number of difficulties. In the so-called clear cases of Rhizoctonia, uncomplicated by other fungi, the dead bushes are found scattered haphazard through an area of tea. It must follow, therefore, that the conditions which lead to the upset of the equilibrium and the transformation of the Rhizoctonia from a symbiont to a parasite must operate in an irregular manner. These conditions, then, become of primary importance and the role of the fungus becomes a minor matter in the causation of the disease.

"When we consider the so-called complicated cases of Rhizoctonia, complicated by the presence of pathogenic fungi such as *Fomes, Poria* and *Rosellinia,* the true position is more apparent. Every one who has had experience of such cases in the field knows that the affected area becomes larger annually, if left alone. Magnificent tea bushes, even show bushes, on the edge of Poria or Rosellinia patch will die unless they are successfully isolated from the advancing Poria or Rosellinia. It would be strange if the mere presence of an advancing fungus like Poria caused an upset of the equilibrim and allowed the Rhizoctonia to do its preliminary work, while the presence of an intervening trench is sufficient to prevent that upset. In such cases the importance of the *Poria, Fomes* or *Rosellinia* is apparent, and the role of Rhizoctonia again becomes negligible.

"It must be admitted that Mr. Park put his suggestions forward tentatively, and one suspects that he has selected this particular mycorrhiza theory partly to provide " an answer to the arguments of both sides." In fact Mr. Park admits that there is but little direct evidence to support his suggestion that, given a condition, either physiological or pathological, which is unfavourable to the bush, the fungus Rhizoctonia is able to get the upper hand and to proceed as a parasite on the very roots in which it has previously been living as a mycorrhiza.

"The importance of Mr. Park's work cannot be disregarded. He has shown that the fungus Rhizoctonia lives within the root tissues of certain plants, tea in particular, as mycorrhiza. As such, the fungus is, in all probability, beneficial to the plant. His investigations, therefore, will be watched with considerable interest.

"The practical agriculturist, however, has a curious problem to consider. On the one hand, he is told that *Rhizoctonia bataticola* is the only parasite

of primary importance, and as such, should be eradicated by all means in his power. On the other hand, the same fungus has been shown to be a mycorrhizal fungus, and as such it is possibly beneficial, because most mycorrhiza are known to be beneficial. In the latter case, it is worthy of encouragement.

"A careful consideration of the known facts shows that there is no sound reason for reconsidering the status of our well-known root disease fungi, or for considering *Rhizoctonia bataticola* to be a parasite of an importance to woody plants, particularly tea with which I am closely concerned. Should satisfactory proof be forthcoming that this fungus is a parasite of woody plants, the status of other root parasites will not necessarily be altered. The position for the practical planter, then, is the same as it was before he heard the name *Rhizoctonia bataticola*. The abandonment of stumping, trenching and other methods of treatment of root diseases for recommendations based on the hypothesis that *Rhizoctonia bataticola* is the primary parasite, would be folly. That was the theme of my first criticism of the claims made for this fungus, and I see no reason for altering that theme until those claims can be substantiated."

In conclusion, Mr. Perch said:—Dr. Small says that this question has been considered in other countries. That is so, and the position in Java which Dr. Steinmann has described is that it is possible that *Rhizoctonia bataticola* is an addition to our list of root diseases. There is a recent article by Professor Briton-Jones, Professor of Mycology at the Imperial College of Agriculture, and his verdict on Dr. Small's work is this:—

> "In his recent publication Dr. Small in his eagerness to establish the fact that *M. Phaseoli* is in his opinion more important than the other fungi associated with root-rot, has made statements which are not in accordance with the true facts."

His Excellency.—We have listened to a very interesting discussion where we find our scientists disagreeing on no doubt a point of great importance. We can only hope that the further experiments that are being carried out will enable them to come to a definite conclusion. I am afraid we cannot hope to settle the point at issue at this meeting.

Mr. R. G. Coombe thanked His Excellency and Mr. Stockdale for permitting the question to be discussed and also Dr. Small and Mr. Petch for their papers.

Dr. Small.—I should like it to be understood, Sir, that I do not imagine for a moment that Mr. Petch has had the last word. I shall have much more to say.

His Excellency.—I think we all feel that it would be useless to prolong this discussion now. This audience is hardly competent to consider it and I think the point had better be argued out in the scientific journals.

His Excellency then requested Mr. T. E. H. O'Brien to read his notes on "Factory procedure and efficiency especially in reference to crepe manufacture."

Some Notes on Factory Procedure and Efficiency, Especially in Reference to Crepe Manufacture.

T. E. H. O'BRIEN, M.Sc., A.I.C.,

Chemist, Rubber Research Scheme, Ceylon.

AS the prosperity of a rubber estate depends on the sale of its produce, the desirability of making a product which will always command full market price will be readily admitted. It will also be agreed that any economy that can be effected in factory costs is as important as economy on other items of cost of production.

In practice however the degree of importance which is attached to factory efficiency varies considerably. By a small minority, rubber "curing" is regarded as a simple procedure which can be left in its entirety to the care of the Rubbermaker. The great majority of planters take on active interest in factory organization, and a smaller number have found by experience that maximum economy and efficiency can only be attained by careful personal attention to detail.

There are two ways in which factory efficiency can influence profits. The first is by causing a direct saving in cost of production. The second is by producing rubber which will always secure top price on the market, and by increasing the proportion of first grade rubber in the total crop.

A visit to a Colombo rubber store where samples from different Estates are laid out is instructive in indicating the variations which exist in appearance of the rubber. Some are very attractive, others are the reverse. Although the less attractive rubber may be nominally up to standard quality, it is likely that there may be difficulty in disposing of it at full market price, whereas the attractive parcels will find ready purchasers. The writer is informed that some estates with a reputation for careful manufacture have a certain market for their produce at top market price even without sampling. There appears to be no reason why every estate should not produce equally attractive rubber. In some cases this would involve replacement or repairs to old machinery, and it may be the policy of the Directors to cur-

tail capital expenditure even if it entails selling the rubber at a slight discount. In other cases however all that is required is adjustment in methods of preparation, and careful attention to detail in the factory.

It is admitted that attractive appearance is no criterion of the inner properties of the rubber and that the home manufacturer would gain if the buyer insisted on uniform inner properties rather than a pleasing exterior appearance. The fact remains that appearance is the criterion on which rubber is judged in the open market, and for the present the producer must aim at satisfying the demands of the buyer, at the same time adopting methods which will tend to uniformity of inner properties.

The following notes deal with various points in rubber manufacture which have a bearing on efficiency and economy.

Crepe Manufacture.

Coagulation.—In Ceylon the usual practice is to coagulate in 50 gallon Shanghai jars. In a large factory this may mean 20 or more separate measurements of latex, water, bisulphite and acid daily.

There is the likelihood that latex in the different jars will vary in colour with the result that when the crepe is blanketed together a streaky appearance will result. This has been recognised by Estates which specialise in sole crepe manufacture and in such factories Shanghai jars are almost invariably replaced by large tanks.

As with appearance so with inner properties of the rubber. It is known that rubber from different fields is liable to vary in such properties as rate of vulcanisation, plasticity, and tensile strength. By bulking large quantities of latex these variations are averaged up. It is recommended that where practicable, Shanghai jars should be replaced by tiled tanks holding several hundred gallons. Careful attention can then be given to dilution and coagulation with benefit both to appearance and inner properties.

Formic Acid.—Formic Acid was introduced to the plantation industry several years ago as a more economical coagulant than Acetic acid. It was adopted by a number of Ceylon estates but received a setback in popularity owing to rumours that crepe prepared with formic acid became streaky during shipment, and that it was unsuitable for certain manufacturing processes. As regards appearance, blanket crepe prepared with formic acid is slightly superior to acetic acid crepe from the same batch of latex, and shows no tendency to become streaky during storage. The statement with regard to manufacturing properties of formic acid rubber was investigated and it appeared that manufacturers of

transparent goods such as teats, considered that these articles when made from formic acid rubber had a slight greenish tint not present in those made from acetic acid rubber. Sample teats were examined by the Technical Committee of the Research Scheme but no difference was detected. The difference therefore is so slight that it can only be detected by an expert, and in view of this and the fact that manufacture of transparent goods represents only a minute part of the world's rubber trade, this can hardly be considered a legitimate objection to the use of formic acid.

The cost of 90% formic acid is slightly less than that of acetic acid (Rs. 18 and Rs. 19 respectively per carboy of 45 lb.) and has a greater coagulating power. Bulk for bulk it is approximately twice as effective as acetic acid, but it is heavier and on a weight basis it is approximately 1·65 times as effective. On this basis the cost of coagulation with acetic and formic acid is 0·21 and 0·12 cents per lb. of rubber. The saving which can be effected by using formic acid may appear small, but on the total output of rubber from Ceylon it amounts to approximately Rs. 100,000 per year.

Milky Serum.—It has previously been pointed out (R.R.S. 2nd Quarterly Circular for 1925, p. 3) that on a number of estates an appreciable amount of rubber is lost in the form of "milky" serum due to incomplete coagulation of the latex. It appears to the writer that this fault is more common now than it was a few years ago, probably owing to the desire to economise on acid. It is however no economy to save a pound of acid if this entails the loss of several pounds of rubber.

Apart from economy there is a belief amongst rubber-makers that correct coagulation is such that a milky serum remains. Apparently this is based on a desire to obtain a soft coagulum, but actually the additional amount of acid required for complete coagulation has little influence on hardness.

The quantity of acid used should be such that the resultant serum is clear or only slightly cloudy. The amount varies considerably on different estates and a case is known of 2 estates within a few miles, on which the amounts of acetic acid required for complete coagulation of 50 gallons of latex at $1\frac{1}{2}$ lb. per gallon are $4\frac{1}{2}$ oz. and $6\frac{1}{2}$ oz. respectively.

Crepe Rolling.

A number of experiments have been carried out by the writer to determine conditions under which machining of crepe can be carried out most efficiently and economically. The experiments are not completed but information is available on a number of points.

In testing the output of a roller it is evident that this will depend on the thickness of the rubber coming from the machine at the time of the test. Owing to the unevenness of crepe rubber it is inconvenient to make direct measurements of thickness. In order to overcome this difficulty samples of rubber taken during the test are carefully weighed and measured, and a figure for thickness is calculated in terms of weight per square foot. This method is equally applicable to tests with grooved or smooth rollers and enables comparisons to be made of machines in different factories. It also provides a tangible basis for advising on methods of crepe rolling. The average thickness of lace crepe as prepared in Ceylon appears to be 50-60 grams (approximately 2 oz.) per square foot.

According to figures received from Malaya the normal thickness of lace crepe there is slightly less than 50 grams per square foot.

Maceration.

Hard or Soft Coagulum ?—It is evident that more power is absorbed in rolling hard coagulum than soft coagulum. A recent test showed that the hardness of the coagulum has no appreciable effect on the output of rubber from the rollers so it is desirable that the coagulum should be soft. Dilution of latex to 2 lb. per gallon provides coagulum of suitable consistency.

Gearing of Rollers.—By gearing of rollers is meant the difference in speed at which the two rolls revolve. It is found that for breaking down coagulum (the first two rollings) it is preferable to have a big speed difference between the two rolls, i.e., a gear ratio such as 17:32. For subsequent rollings a smaller speed difference, such as 17:21, gives the best results. Thus if a battery includes two grooved rollers it would be advisable to have one geared 17:32 for breaking down the coagulum, and one geared 17:21 for completion of rolling. If only one machine is used it should be geared 17:21, and the coagulum should be cut into thin slices so that it feeds easily. The writer's experience is that the equivalent of one rolling is often lost owing to feeding thick lumps of coagulum into the machine. The slices of coagulum should not exceed 3 inches in thickness.

Speed of Rolling.—The present tendency in Ceylon factories is to speed up machinery, and in at least one case a grooved roller is operating at 35 revolutions per minute.

Some tests were carried out on a 22 in. grooved roller which could be run at either 16 or 27 revolutions per minute. It was found that 3 rollings at the lower speed was approximately equal in effect to 4 rollings at the high speed. Moreover the width of the rubber was greater (17 in. compared with 15 in. - 16 in.) as a result of slow rolling, which would benefit the output of the

smooth roller. The increased efficiency of slow rolling appeared to be partly due to the rolling *per se*, and partly because the cooly could feed the machine more uniformly at the lower speed.

At another factory a grooved roller is provided with a two speed gear giving respectively speeds of 35 and 18 revolutions per minute. The first 3 rollings are done at high speed but it is found necessary to do the last rolling at low speed before passing the rubber to the smooth roller.

There is little doubt that fast rolling consumes a disproportionate amount of power and causes increased wear of bearings. Crepe rollers are usually designed by the makers to run at a peripheral speed of 50 feet per minute (approximately 16 revolutions per minute for 12 in. diameter rolls). If these are operated at 35 revolutions per minute the stresses are probably four times as high as they were designed to withstand.

The writer's opinion at present is that 20-22 revolutions per minute is a suitable speed for a macerating roller.

Thickness of Rubber.—Tests indicate that the output of a smooth roller is not influenced by the thickness of the rubber which is fed in to it. Therefore in order to obtain maximum output from the grooved rollers the aim should be to roll the rubber to the maximum thickness which can be fed in to the smooth roller without tearing.

Number of Rollings and Output.—It is considered that under normal conditions, five rollings in the grooved roller should be sufficient, and that the output of a 15 in. grooved roller running at 20 revolutions per minute should be 225-250 lb. of dry rubber per hour.

Smooth Rolling.

The chief factor which governs the output of lace crepe is "slip" of the wet rubber in the rolls. This is not surprising to anyone who has tried to walk on a wet floor in crepe soled shoes, but it is somewhat disconcerting to find that the efficiency of a smooth roller may be as low as 33%, i.e., that the rolls move a distance of 3 feet for each foot of crepe which emerges from the machine. In this calculation the amount of slip is calculated on the slow moving roll so the amount of slip of the fast moving roll is correspondingly greater. Even in grooved rollers the amount of "slip" is considerable but is less important owing to the greater thickness of the rubber which is being dealt with.

Hairline Grooving of Smooth Rollers.—As a preventive of "slip" in smooth rollers, it is becoming common practice to mark the rollers with fine spiral grooves. A satisfactory specification is double spiral grooving, ten cuts to the inch, 1/64th inch deep, cuts set at 45° to the direction of travel of the rollers.

Claims have been made that this grooving gives a phenomenal increase in output of the rollers, but it appears to the writer that these claims require a certain amount of qualification.

A test was carried out on a 15 in. Bridge's roller, with chilled steel rolls, geared 17:32, operating at 28½ revs. per minute, which had been provided with hairline grooving to above specification. The output of the roller proved to be 166 lb. per hour but the thickness of the crepe was considerably greater than the Ceylon average (87 grs. per sq. foot). At a thickness of 60 grs. per square foot the output would be 114 lb. per hour which is not higher than would be expected at this speed.

In another experiment the output of a roller with cast iron rolls was measured, and the rolls were then sent in to Colombo to be remachined and marked with hairline grooves. The efficiency of the roller increased from 46·3% to 51·7% but it is difficult to say how much of this was due to the grooving.

The writer's general conclusion is that for modern chilled steel rollers hairline grooving is essential, and that this treatment brings them to approximately the same level of efficiency as cast-iron rolls without hairline grooving. Grooving of cast-iron rollers is probably not to be recommended owing to the comparatively rapid wear which takes place.

Speed of Rolling.—This point is largely bound up with the question of " slip " and texture of the rollers. A case is known in which a modern roller geared 17:32 marked with hairline grooving, operating at 18 revs. per minute, gives a larger output than a roller of similar size also with hairline grooving operating at 27 revs. per minute. The respective efficiencies of the rollers are 63% and 46·5%. Arrangements have been made for the speed of the latter machine to be altered to 21 revs. per minute and a test will then be made to see if the efficiency is increased. At present the writer's opinion is that excessive speed is not desirable and that 22 revs. is a suitable maximum for smooth rolling.

Gearing of Rollers.—It is well known that a smooth roller with a large difference in speed between the two rolls, such as 17:32 produces a smoother crepe than a roller geared 17:21. This advantage becomes more pronounced as the rollers become worn. It has also been claimed that the output from a roller geared 17:32 is larger and that the crepe dries more quickly.

A comparison between a 17:21 and 17:32 roller showed that the latter had an output 7·5% higher than the other. Both rollers were remachined and marked with hairline grooves and the difference in output was then 12%. In both cases the difference was approximately proportional to the increased width of crepe from the 17:32 machine.

Regarding rate of drying it appeared that there was a slight difference in favour of the smooth crepe from 17:32 rollers.

When ordering new rollers it is very desirable that 17:32 gearing should be specified, but it is doubtful whether the expense of altering existing rollers is justified. 17:32 rollers are essential if the rubber is to be marketed in the form of lace crepe.

Width of Crepe.—Average estate rollers are 15 inches wide and it should be practicable to feed them with rubber 12 inches wide, without danger of the edges of the crepe becoming dirty. As the rollers become worn in the centre, it is the custom on some estates to insert hoppers so that the rolling width is reduced. Cases have been seen in which the rolling space has been reduced to as little as 8 inches. It should be emphasised that when a roller has reached a stage that its full width cannot be utilised, it is an economy to send it in to be remachined.

Drying of Crepe.

The importance of adequate ventilation of air-drying sheds was dealt with in a report published in R.R.S. 3rd Quarterly Circular for 1927, p. 7, and owing to exigencies of space it is not proposed to deal fully with the subject here. It will suffice to say that successful ventilation depends on creating an upward draught through the rubber, and for this it is essential to provide ample roof ventilation.

Improvements in ventilation can be expected to give a direct return by improving the proportion of first grade rubber, especially during wet weather.

Blanket Crepe or Thin Crepe?

Crepe rubber in Ceylon is usually marketed in the form of "blanket" crepe whereas in other countries it is marketed as thin or "lace" crepe. There is continual discussion in Ceylon whether it would not be preferable to market thin crepe, and curiously enough in other countries the question of marketing blanket crepe is discussed.

Arguments in favour of thin crepe.—1. Blanketing the crepe, involving at least 3 rollings, is avoided. Dry rolling of rubber absorbs a considerable amount of power.

2. Slight differences in colour which are not evident in lace crepe show up when the rubber is blanketed and it may then appear streaky or slightly off colour.

Counter Arguments.—1. When marketing blanket crepe no great attention need be paid to the texture of the lace crepe, provided it is clean and sufficiently even to dry uniformly. It can be pulled down from the drying racks in bundles.

On the other hand if it is to be marketed as lace crepe, great care must be exercised that the crepe is smooth and even and reasonably free from holes. It must be carefully hung to dry so that it does not become creased and carefully taken down and folded. When machinery is in perfect order satisfactory crepe can be prepared in 6 rollings, but the quality cannot be maintained if the rollers are allowed to become worn.

2. When marketed as thin crepe, the rubber must be left to dry until every opaque spot has disappeared otherwise fungal spots will develop after packing. In making blanket crepe it is permissible (although not desirable) to take down the crepe when occasional opaque spots remain as these are eliminated during blanketing. This may make a difference of 2-3 days in period of drying.

3. As regards packing there is little to choose between the amounts of thin crepe and blanket which can be packed in a chest, provided that both are made efficiently. If the lace crepe is uneven in texture, contains many holes, or is abnormally narrow then there is considerable loss in packing space.

4. Manufacturers prefer blanket crepe for certain purposes and there is always a steady demand for "Ceylon Blanket." If thin crepe is manufactured the individuality of Ceylon rubber is lost and it must be sold in competition with other countries. The Manager of one of the largest rubber producing Companies in Ceylon informed the writer recently that he had considered carefully the question of blanket crepe and thin crepe, and had decided not to make any change for the above reason.

In the writer's opinion this consideration outweighs any arguments in favour of thin crepe, particularly in the present state of the rubber market.

Packing of Rubber.

In visiting estates it is noticeable that there are considerable variations in the amount of crepe or sheet rubber packed in chests of similar dimensions. The importance which is attached to economical packing appears to depend largely on whether the rubber is to be sold in Colombo or London. To take for example 2 estates in the same Company manufacturing blanket crepe. The amounts packed per Momi chest are 130 lb. and 150 lb. respectively. Taking the cost of a Momi (plank) chest at Rs. 1·30, the saving in cost due to superior packing amounts to 0·13 cents per lb. if the rubber is sold in Colombo. Shipping charges are made according to volume irrespective of weight, the approximate charge to London being Rs. 4·20 for a chest 19 in. by 19 in. by 24 in. In this case the cost of transport to London works out at 3·23 and 2·8 cents per lb. showing a further saving of 0·43

cents per lb. due to superior packing. This extra cost falls on the buyer or seller according to whether the rubber is sold in Colombo or London.

The extreme cases which have been noted are an Estate packing 150 lb. of smoked sheet per Momi chest, and an Estate packing 225 lb. smoked sheet per Venesta (Plywood) chest. After allowing for the difference in cost of chests the saving in packing and transport to London is 0·77 cents.

The question is frequently discussed whether Momi (plank) chests or plywood chests are most economical. Both have the same external dimensions but the internal capacity of the plywood chest is approximately 10% greater than the Momi. On the other hand the plywood chest costs more, the prices in a specific instance Re. 1·34 and Rs. 2·23 each including setting up.

Plywood chests have an important advantage if rubber is being shipped to London. The dock authorities charge a consolidated rate of 60/- per ton for handling and sampling rubber, but if packed in plywood chests there is a reduction of 25%. The reason for this is that plywood chests are uniform in " tare " and it is only considered necessary to open 10% of the chests for taring, whereas with Momis, each chest is opened.

A Colombo firm have furnished a statement showing the cost of shipping a consignment of rubber to London in Momi and plywood chests. The statement is given as an Appendix and shows a nett saving of 0·47 cents per lb. by shipping in plywood chests.

Disinfectants in Rubber Manufacture.

The use of para nitrophenol for prevention of mould in smoked sheet is now well established in Ceylon, and gives good results if the treatment is efficiently carried out.

If a pile of sheets is placed in a jar of para nitrophenol it is obvious that the centre sheets will not come properly into contact with the solution. The sheets should at least be placed one by one into the solution. It is preferable to have 2 jars of solution and to transfer the sheets singly from one jar to the other, repeating the operation about 5 times. In this way 175-200 lb. sheets can be treated per hour by one cooly.

The alternative method of using p.n.p. by adding it to the latex with the coagulant gives good results on some estates but is unsatisfactory in other places owing to rapid clotting of the latex.

Para nitrophenol also prevents development of fungal spots in crepe but unfortunately soaking of the crepe in a solution as dilute as 1 part in 10,000 is liable to cause slight discoloration of

the finished blanket. It has been found in several tests that p.n.p. can be added to latex in the proportion 1.4000 (based on weight of rubber) without causing discoloration of the finished blanket. This small amount of p.n.p. is not sufficient to prevent gradual development of spots under a severe laboratory test but is considered sufficiently effective to prevent spotting under estate conditions of manufacture and storage. It should be mentioned that a sample of crepe prepared from latex from newly opened cuts, containing the above proportion of p.n.p. proved to be slightly off colour, and it remains to be seen whether there would be any discoloration in very wet weather, which is when the treatment would be particularly useful.

It may be thought that there is little in the foregoing paper which gives scope for substantial reductions in cost of production, and there are doubtless many estates where economy and efficiency in the factory have been taken to the limit. It is equally true that in many factories considerable improvement can be effected both by direct savings and by increasing the proportion of crop which secures full market price.

Appendix.

Comparison of Momi and Plywood Chests for Packing Rubber.

	Tare.	Nett Weight of Rubber.	Gross Weight.	Measurement.	Price.
Momi	22 lb.	180	202	5 C.—ft :	1/31;
Plywood	14 ,,	200	214	5 ,,	2/23;
	(. : Chest 1/10	Hoop-iron -/15		setting up -/06	)
	) ; ,, 2/15	complete		,, -/08	

Example :—Shipment of 35,000 lbs. nett weight of rubber.

Number of chests required :— Momi 200. Plywood 180

Gross weight ... 40,400 lbs. 38,520 lbs.

	Momi. Rs.	Momi. Cts.	Plywood. Rs.	Plywood. Cts.
Cost of Chests	262	00	401	40
Transport to Colombo @ -/01 Ct. per lb. gross weight	404	00	385	20
Ocean freight @ Rs. 4 :20 per chest	840	00	756	00
	1,506	00	1,542	60
London charges : Consolidated Rate 60*s.*/- per ton gross weight (@ Ex : 1*s.*/6*d.* - Rs. 40/-)	721	40	515	89
	Rs. 2,227	40	2,058	49.
Cost per lb.	Rs. 6 :19 Cts.		5 :72 Cts.	

Saving on Plywood chest 0 :47 *Cts. per lb.*

	Rs. 687	85
Less 25% for 10% Taring only -	,, 171	86
	Nett Rs. 515	89

Discussion.

His Excellency said that they would wish him to express their thanks to Mr. O'Brien for his paper which was not only interesting, but given at a trying time in the history of the industry. Some of the hints which Mr. O'Brien gave would be useful to those engaged in the production of rubber. Some of the points ought to have further discussion especially in the use of large tanks as against Shanghai jars. He would ask Mr. Dias if he had experimented with large tanks.

Mr. C. E. A. Dias said that most of his rubber was made into smoked sheets, but he should say that he had seen those large tanks in Java and Sumatra, and he thought that it was very useful to get all the rubber in one good quality. At the present stage, he (the speaker) did not think it wise to spend large sums of money on expensive machinery etc., What was wanted at the present time was a method for cheap production.

In reply to a question by Major Oldfield, Mr. O'Brien stated that he thought that as far as lump was concerned, that was really the only latex rubber that did not get top prices.

Mr. A. R. Westrop gave figures of the large quantities of rubber dealt with in the Dutch East Indies. One place handled the rubber of 140,000 acres. They did not even use chests. The rubber was brought in trays and lumped in like dough, then through a hydraulic process and within twenty-four hours of its arrival at the factory was ready for shipment.

Mr. Bourchier asked whether Mr. O'Brien would advocate artificial drying of crepe rubber.

Mr. O'Brien.—Actually there are two points of view. The first is that Ceylon blanket rubber has achieved its reputation as being suitable for certain purposes and it still has that reputation although probably a good deal less than half the rubber in the Island is machine dried. Our staff at the Imperial Institute has again come to the same conclusion that machine-dried rubber has the advantage of being more plastic than air-dried rubber.

His Excellency thanked all those who took part in that discussion and he hoped that the hints given by Mr. O'Brien would be taken up by the planters.

(The proceedings of the afternoon session were then brought to a conclusion).